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INTERNATIONAL AMITY AMONG FORESTERS

From a letter by W. B. Greeley to Prof. R. S. Troup, printed elsewhere in this issue, we are glad to learn that the American foresters contributed a modest sum of money towards a British fund for the creation of a memorial to the late Sir William Schlich. More significant than the money, however, is the manifestation of the international solidarity of foresters, who, regardless of creed or origin, gladly paid homage to a distinguished brother forester, who, although of German nativity and training, worked for the cause of British forestry.

Colonel Greeley's proposal to use the major portion of the fund for endowing a forestry scholarship at Oxford, open to students from all parts of the English-speaking world, should promote the good-fellowship of English-speaking foresters.

This appreciation of a leader in forestry in a foreign land should be productive of awakened appreciation of the work of the leaders of forestry in our own country. The profession, possibly because it is still young and aggressive, lacks the mellowness of ripe age which brings charity and keener realization of the obstacles which the earlier foresters had to overcome. The works of Dr. B. E. Fernow—the doer—and of Prof. Filibert Roth—the teacher—still remain largely unappreciated by the rank and file of our profession.

At a time when the world is still torn by racial hatreds, economic rivalries, when the strong nations still covet the natural riches of the weak, when might still rules over right and social justice, it is refreshing to record an expression of international sympathy and understanding among foresters, and know that the Brotherhood of Science is marching on.

THE BIOLOGICAL SIDE OF THE BUSINESS OF FOREST AND FORAGE PRODUCTION

By Walter P. Taylor
Division of Biological Investigations, Bureau of Biological Survey

In order to keep up our national well-being we must maintain the supply of wood and wood products from the forest and of livestock from the grazing ranges. As man acquires vision and can see into the future he must inevitably be increasingly concerned with problems of conserving and increasing his supplies of food and other essential materials. Even in 1669 Colbert, Louis XIV's famous prime minister, noting the diminution of the forests, is reported to have said "France will perish for lack of wood."[1] Simply to retain what we have left of forest on the one side and forage on the other we must put administration on a sustained yield basis. This is thoroughly realized by the far-sighted among those in close touch with our national situation. Our utter failure to date to accomplish sustained yield in any large way either in forest or forage is enough to give pause to all thoughtful persons.

Consider the case on the forester's side. So far from sustained yield being attained the depressing fact is that we have been unable to make up for current losses. The annual toll taken from the forest in the United States in 1923 was no less than 25 billion cubic feet, while the annual growth was but 6 billion.[2] Of our original forest of 822 million acres of virgin timber, in 1923 only 138 millions were left, while 250 million acres were of comparatively inferior culled and second-growth forest, and 81 million acres had been cut or burned over in such a way that they were unproductive and evidently would not reforest under natural conditions.

Nor is the case any better on the side of the forage resources; in truth there is every reason to believe it is much worse, since the grazing ranges, being largely on the public domain outside the national forests, have had much less regulation than have the forests. Overgrazing and range depletion seem to have accompanied the practice of unregulated grazing since the dawn of history.[3] The present time is no

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[1] Buttrick, American Forests and Forest Life, 32: 217-220, etc., 1926.

[2] Greeley, Clapp, Smith, Zon, Sparhawk, Shepard, and Kittredge, Yearbook U. S. Dept. Agric., 1922, pp. 83-180, 1923.

[3] See Barnes, The Story of the Range, U. S. Dept. Agric., p. 11, 1926.

exception, as anyone who has traveled in the range country will quite likely admit without argument. Note the extent of the resource involved: "the area of land in the United States used for grazing, excluding crop lands pastured part of the year, is about 1,055,000,000 acres, or 55 per cent of the total area of this country."[4] "Man's greed to obtain something for nothing has never yet allowed him to be content with a moderate profit."[5] There is of course no great probability of sustained yield under such conditions.

Careful regulation, both of forests and forage, is essential to America's future welfare. This regulation must be on an intelligent, i.e., a scientific foundation. "The routine application of conventional methods will no longer suffice."

At present administrators must often go it blind for lack of a proper scientific basis for management. Such a basis must be developed by research. A far-reaching campaign of education is needed so the people will realize the need for adequate studies, provide the necessary funds and facilities, and act on the results. Research, far from being an expensive luxury, is a corner-stone of the whole enterprise of civilization. It is perhaps the greatest of all builders of opportunities for labor, capital, and higher living standards.

Forest and grazing research, up to date, is amazingly productive and valuable when we remember the relatively small financial and moral support the people have given it. It is certain, however, that the discharge of present-day obligations, or perhaps better, the solution of present-day problems, requires an expanded and more comprehensive program of research. Take the forest, for example. Although published writings on silviculture are relatively numerous, and current research projects not a few, one must seek far to discover works and projects in *forest biology,* although the problems of forest production are fundamentally biological. The forest is a community of specialized living organisms, including certain plants and animals. The trees, to which so large a percentage of research is directed, are but one expression of the life in this community. The grass, weeds, and browse are others, and the birds, mammals, insects, reptiles, and lower animal forms are still others. *In order to secure the best results in the*

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[4] Barnes, l. c., p. 2, quoted from Yearbook, Dept. of Agric., 1923.
[5] Barnes, l. c., p. 7.

production of trees we must acquire a scientific knowledge of the predominant organisms throughout the entire forest biota.[6]

Similarly with *range biology.* Writings on forage and its production, and on the regulation of the grazing range, are becoming more numerous, and the number of excellent pieces of research work in range regulation increasing. But references to the biology of the range are so scattered as to be almost non-existent, and this, in spite of the fact that forage production, like forest production, is fundamentally a biological enterprise. A little consideration of the subject demonstrates the need for increased attention to the birds, mammals, reptiles, amphibians, insects, and other groups of living forms characteristic of the grazing ranges. *In order to secure the best results in the production of livestock we must acquire a scientific knowledge, not only of the multitudinous forage plants, but of the predominant organisms throughout the biota of the grazing range.*

In both these provinces we should endeavor to form the habit of visualizing the problems as wholes. As investigators we are separated by various institutional lines, such as Forest Service, Biological Survey, college of agriculture, Carnegie Institution, etc., which may appear to make difficult the unification of effort, but which may be overcome by effective cooperation across administrative lines. These lines do not appear upon the face of nature, and we should do well to remember that we are or ought to be working as partners in the same great enterprise.

In the following outline I have tried to present some of the matters which should find place in the subject matter of forest and range biology. Of course the outline is not complete. Its possible ramifications are interminable. An attempt is made, however, to isolate portions of the vast network of life of which forest and forage are important parts so as to illustrate the need for investigations on a broad and inclusive basis.

BIRDS AND MAMMALS AND FOREST PRODUCTION

1. Birds and mammals may be either harmful, or beneficial, or both to natural reproduction of forest.
   (1). Some instances of damage reported.
      A. Where porcupines are numerous and natural reproduction scarce, as is often the case on cut-over, burned-over, or overgrazed areas, or where the stand of forest trees

[6] Shelford, Ecology, 7: 389, 1926; see also Munns, Sci. Monthly, 18: 322-330, 1924, and Journal of Forestry, 24: 911-914, 1926.

subject to attack is scattering, the animals may endanger the future forest through their bark-consuming habits, their work being of special significance and seriousness on the younger trees.

a. Hunter[7] (Porcupines on the Routt National Forest, Colorado, damage lodgepole pine, Engelmann spruce, and alpine fir; they are also a source of injury to livestock).

b. Pearson[8] (On one area of 125 acres on the Coconino National Forest, Arizona, bearing an average stand of 80 seedling western yellow pines per acre between 1 and 3 feet in height scarcely half of the plants escaped porcupine injury).

c. Couch[9] (Porcupines are particularly destructive to pine forests in southeastern Washington).

d. Taylor[10] (Porcupine damage serious in certain localities of the Southwestern United States, especially the San Juan, Carson, Coconino, and Tusayan National Forests).

e. Gabrielson and Garlough[11] (Extensive porcupine damage reported on the Crater, Malheur, and Fremont National Forests in Oregon).

B. Tree squirrels of various sorts, as well as chipmunks and other rodents, consume quantities of conifer seeds and sometimes cut off cones; squirrels also cut off portions of branches with their foliage thus reducing the effectiveness of the tree's food manufactory.

a. Cox[12] (Suggests that if western yellow pine bore a uniform crop of seed each year the animals which feed upon this seed might become so numerous as to seriously endanger the existence of the tree as a part of the forest).

b. Toumey[13] (Squirrels destroy buds in spruce plantations; rodent problem important).

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[7] Unpublished manuscript, Forest Service, 1918.
[8] Bull. No. 1105, U. S. Dept. Agric., p. 135, 1923.
[9] The Murrelet, 6: 39, 1925.
[10] Unpublished notes.
[11] Unpublished notes.
[12] Bull. 98, Forest Service, U. S. Dept. Agric., p. 16, 1911.
[13] Seeding and Planting, pp. 38, 143-145, 176-181, etc., 1916.

c. Bowles[14] (Estimates hundreds of thousands of dollars damage done to Douglas fir in western Washington by California gray squirrel).

d. Pearson[15] (Obvious effect of cutting by squirrels of terminal twigs from older western yellow pine trees is to lower capacity of crown as a food laboratory).

e. Taylor[16] (Abert squirrels, occurring broadly through the western yellow pine forest of Arizona, ordinarily do little damage but in a few places have defoliated and killed individual trees).

C. Rabbits or hares may become so numerous that they consume or destroy a large amount of natural reproduction.

a. Fisher[17] (Rabbits in England a veritable scourge to forestry and agriculture; render reproduction of trees exceedingly difficult and expensive).

b. Farrow[18] (Great increase of rabbits as a result of killing carnivorous animals has prevented considerable areas in England from becoming natural pinewood and is apparently bringing on degenerative changes in existing woodland).

c. Baker, Korstian and Fetherolf[19] (Snowshoe rabbits eat buds and tender twigs of conifers in winter, and are a menace to natural reproduction and plantations in the Wasatch Mts., Utah).

D. Wood rats or pack rats apparently constitute a serious handicap to natural reproduction of Jeffrey pine on the Angeles National Forest in California.[20]

E. Mice of various kinds and other small rodents may damage the forest, especially in eating seed and feeding on the bark of seedlings.

a. Willis[21] ("Rodents, and white-footed mice in particular, destroy a large per cent of our field-sown

[14] American Forestry, 26: 26, 1920.
[15] Bull. No. 1105, U. S. Dept. Agric., p. 135, 1923.
[16] Unpublished notes.
[17] Forest Protection, in Schlich's Manual of Forestry, Vol. IV, pp. 3-4, 1895.
[18] Journal of Ecology, 5: 1-18, 1917.
[19] Ecology, 2: 304-310, 1921.
[20] Munns, Journal of Forestry, 15: 417-423, 1917.
[21] Proc. Soc. American Foresters, 9: 378, 1914.

seeds. The rodent loss is so high that is guarantees failure of seeding. Either the rodent must be controlled or seeding must be given up.").

b. Flint[22] ("On the Long Pines division of the Custer Forest in Montana careful observation leads to the belief that mice do far more damage to yellow pine seedlings than heavy damage by cattle.").

c. Korstian[23] ("In some cases 90 per cent of the total production of acorns was consumed by animals." This was at the Appalachian Forest Experiment Station. Among the mammals and birds feeding on acorns were deer, cattle, hogs, squirrels, chipmunks, rabbits, mice, turkeys, jays, and robins).

F. Prairie dogs, jack rabbits, marmots, and other grass and browse consuming rodents, where they occur in the forest, tend to promote overgrazing with consequent vegetation removal and erosion.

G. Deer, where abnormally numerous, as on the Grand Canyon National Game Preserve on the Kaibab National Forest, may do much damage to natural reproduction.

a. Fisher[24] (Game animals, deer, etc., injure the forest by eating the fruit of trees, biting off buds and young shoots, trampling down seedlings, breaking off leaders, bending down stems and barking poles).

b. Crampton[25] (Overstocking with deer in England is one cause of alteration of plant associations).

c. Morse, Swartz, and Swapp[26] (Up to 100 per cent of the natural reproduction of western yellow pine, Douglas fir, Engelmann spruce, white fir, and aspen on the Kaibab National Forest, Arizona, may be destroyed by deer on their summer range).

d. Goldman[27] (Kaibab deer are destroying the natural reproduction of their own forage and injuring young yellow pines by nibbling at tips).

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22 Service Bull., Forest Service, 8 : 6, 1924.

23 Mimeographed circular of activity of Appalachian Forest Experiment Station [March, 1925], pp. 10-11.

24 Forest Protection, in Schlich's Manual of Forestry, Vol. IV, p. 84, 1895.

25 Proc. Roy. Phys. Soc. Edinburgh, 19 : 24, 1913.

26 Unpublished manuscript.

27 American Game, 15 : 28-31, 1926.

H. Birds consume the seeds of conifers. The amount of seed destroyed as compared with that disseminated is unknown. The proportion probably varies with the seed-loving species.

a. Toumey[28] (Mourning dove, junco, blue-jay, Canadian jay, blue-headed grosbeak, redpoll linnet said to be particularly harmful in the West; English sparrow, blackbird, robin and finch in New England and the Lake States).

b. Pearson[29] (*Junco dorsalis* ". . . plucks the seed coats and cotyledons from young seedlings [western yellow pine] and even cuts down the entire plant." But "The beneficial effects of birds as a class in destroying insects undoubtedly far more than offsets any damage which may be charged against them").

(2). Suggestions as to how animals may assist natural reproduction of forest trees.

A. Squirrels and certain other rodents may be an important or even the important means of dissemination of certain forest trees.

a. Hofmann [30] ("The production of heavy crops of seed which is a favorite food of the indigenous rodents," and the "caching of seed by rodents in the forest floor," are among the factors which give the Douglas fir a prominent place in the forests of the Northwest).

b. Cram[31] (Red squirrel assists in replanting hardwoods, especially oak, beech, and hickory).

B. Woodpeckers and certain other birds are foremost in forest protection owing to their destruction of insect enemies of trees.

a. Beal[32] ("Of all birds that further the welfare of trees, whether of forest or orchard, woodpeckers are the most important").

b. Certain mammals, especially rodents, may also consume insects injurious to trees, though few or no studies to determine this point have been made.

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[28] Seeding and Planting, pp. 350-353, 1916.
[29] Bull. No. 1105, U. S. Dept. Agric., pp. 134-135, 1923.
[30] Ecology, 1:53, 1920; Sci. Monthly, March, 1923, pp. 280-283.
[31] Journal of Mammalogy, 5: 40-41, 1924.
[32] Biol. Surv. Bull. 37, p. 8, 1911.

C. Certain birds help to disseminate and protect trees and shrubs.

a. Forbush[33] (". . . birds are instrumental in extending the growth of the woodlands and thickets in which they dwell").
b. Adams[34] (Scattering of seeds by birds and other wild animals a method of reforestation).
c. Sayle[35] (Viability of seeds of apple, grape, strawberry, and cherry destroyed by passage through the digestive tract of pigeons).
d. McAtee[36] (Reviews a late work of Woodruffe-Peacock according to which whitethorn seeds which have traversed the alimentary tracts of birds germinate a year ahead of those gathered by man. In another paper McAtee points out that the effective distribution of the best timber trees, as the pines, hickories, oaks, and chestnuts, occurs in no other way than through transportation by birds and rodents).[37]

D. Carnivorous animals (mammals, birds, reptiles) may assist natural reproduction of trees by feeding on certain rodent pests; they may also hinder natural reproduction by feeding on rodents which assist therein.

a. Fisher[38] (Destruction of birds of prey and smaller carnivora by British game keepers has allowed rabbits and wood pigeons to increase enormously so as to become a scourge).
b. Cox[39] (Believes persistent trapping of pine marten which feeds on squirrels ". . . has, by permitting an abnormal increase in the squirrel population, had an appreciable effect upon tree reproduction in certain places").
c. Baker, Korstian, and Fetherolf[40] (Destruction of

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[33] Useful Birds and Their Protection, especially pp. 92-110, 1907.
[34] Roosevelt Wild Life Bull., 1: 493-496, 1923.
[35] The Auk, 41: 474-475, 1924.
[36] The Auk, 41: 499, 1924.
[37] Roosevelt Wild Life Bull., 4: 101, 1926.
[38] Forest Protection, in Schlich's Manual of Forestry, Vol. IV, pp. 3, 4, 84, 1895.
[39] Bull. 98, Forest Service, U. S. Dept. Agric., p. 16, 1911.
[40] Ecology, 2: 304-310, 1921.

coyotes in Wasatch Mountains, Utah, has favored increase of snowshoe rabbits).

d. Farrow[41] (The natural enemies of rabbits, in England, such as stoats, have been kept down, and rabbits have increased so as to exert great influence on the vegetation, including as Farrow later explains, the pinewood).

e. Musgrave[42] (Mountain lion, southwestern United States, eats porcupines, which animals are in some places, according to many observers, injurious to natural reproduction).

E. Certain burrowing rodents and other animals help to cultivate the soil, their work very possibly being of enormous importance in certain localities.

a. Darwin[43] ("Worms prepare the ground in an excellent manner for the growth of fibrous-rooted plants and for seedlings of all kinds").

b. Seton[44] (Suggests gophers of Manitoba are a substitute for Darwin's earthworms as regards soil-making).

c. Nelson[45] (Work of pocket gophers ". . . often of the most beneficial character" in constantly bringing subsoil to surface and burying humus).

d. McLean[46] ("The constant excavation of the soil [in South Brazil] by mammals and the large iguana lizards is a noteworthy factor, especially in any consideration of nitrification").

e. Henry[47] (A quantitative determination [France] showed that earthworms, together with small worms and small invertebrates, consume probably not less than one-fourth or one-fifth of annual accumulation of leaf-litter. When forest soil is laid bare it is aban-

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[41] Plant Life on East Anglian Heaths, 1925, p. 7 and following.

[42] Journal of Mammalogy, 7: 284, 1926.

[43] The Formation of Vegetable Mould, authorized ed., 1896, p. 309.

[44] "Agr. Rep. Mam. for 1882, pub. Winnipeg, 1883, pp. 169-172," not seen; see also Life Histories of Northern Animals, Vol. I, pp. 578-586, 1909.

[45] Nat. Geog. Mag., May, 1918, p. 502.

[46] Journal of Ecology, 7: 123, 1919.

[47] See Wackerman's review of this paper, Journal of Forestry, 24: 454-455, 1926.

doned by worms, which migrate to places covered with leaf litter).

F. The hair, feathers, excreta, bones, and bodies of the animal population undoubtedly tend to enrich the soil of the forest although quantitative studies are lacking.

a. Grinnell[48] (Excreta of the pocket gopher in California is deposited underground at a depth of six inches).

b. Hayes and Elton[49] (Birds believed to contribute in an important way to maintenance of abundance and variety of life on Spitzbergen and Bear Island by bringing to land as residue of their marine food the principal supply of nitrogen upon which the plants subsist and which is therefore essential to the existence of various chains of organisms).

c. Andrews[50] (Bird waste helps in natural betterment of the soil).

2. Relation of birds and mammals to artificial reforestation by direct seeding.

(1). Certain seed-loving rodents are serious obstacles to successful reforestation by direct seeding.

A. Dearborn[51] (In a Black Hills planting the destruction of seed by chipmunks and white-footed mice was so serious as to threaten the practicability of reforestation).

B. Munger[52] (In the Douglas fir region of the Pacific Coast rodents ". . . may prevent a sowing operation from being successful, even when all other conditions are favorable").

C. Greeley[53] (Destruction of seed by rodents probably the most serious obstacle to direct seeding on the national forests).

D. Pearson[54] (Direct seeding a total failure throughout the

48 Journal of Mammalogy, 4: 147, 1923.
49 Journal of Ecology, 11: 214-286, 1923; also see McAtee, The Auk, Jan., 1924, p. 191.
50 The Auk, 48: 479-484, 1926.
51 U. S. Dept. Agric., Biol. Surv., Circular No. 78, p. 1, 1911.
52 Proc. Soc. Am. For., 7: 187-196, 1912.
53 Proc. Soc. Am. For., 8: 261-277, 1913.
54 Rev. Forest Service Investigations, 2: 82-85, 1913.

district [Arizona and New Mexico] as a result of rodent operations and to a less extent the work of birds).

E. Willis[55] (Studies on the Columbia National Forest indicated that "The rodent loss is so high that it guarantees failure of seeding").

F. Toumey[56] ("Almost without exception regeneration by direct seeding throughout the entire Rocky Mountain and Pacific Coast regions is impossible without protecting the site from rodents").

G. Robertson[57] (White pine seeding in New Brunswick unsuccessful due to rodents, but under suitable conditions spruce highly successful).

H. Taylor and Gorsuch[58] (In controlled experiment on Coconino National Forest, one seedling western yellow pine raised in seed bed open to stock and rodents, four seedlings raised in seed bed open to rodents except rabbits, and birds, but not to stock, while 269 seedlings grew on seed bed protected from stock, rodents, and birds).

(2) Birds also take toll of seeds under the direct seeding method.

A. Pearson[59] (Poisoning of seeds, Southwestern District, might be made effective against rodents, but not birds; *Junco dorsalis* did much damage).

B. Hayes[60] (Rodent and bird effects serious in Rocky Mountain District).

C. Toumey[61] (Mourning dove, junco, bluejay, Canadian jay, blue-headed grosbeak and redpoll linnet reported particularly harmful in the West; English sparrow, blackbird, robin and finch harmful in New England and Lake States).

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[55] Proc. Soc. Am. For., 9: 365-379, 1914.
[56] Seeding and Planting (New York, Wiley), pp. 176-181, 1916.
[57] Journal of Forestry, 24: 260-264, 1926.
[58] Unpublished manuscript.
[59] Rev. Forest Service Investigations, 2: 82-85, 1913.
[60] Rev. Forest Service Investigations, 2: 86-92, 1913.
[61] Seeding and Planting (New York, Wiley), pp. 350-353, 1916.

D. Taylor and Gorsuch[62] (Rocky Mountain jay and flicker observed feeding among seedlings of western yellow pine on the Coconino National Forest).

(3) Certain squirrels cache quantities of pine cones which constitute an important source of seed for planting operations.

A. Toumey[63] (Collecting from squirrel hoards a recognized method of securing seed for planting).

B. Tillotson[64] ("Squirrel caches are usually by far the best places from which to obtain cones. Pine squirrels collect large quantities, and chipmunks and mice lay by smaller stores." Cones of the following often obtained from caches: Douglas fir, Engelmann spruce, western yellow pine, lodgepole pine, western white pine. Small red squirrels the greatest collectors, their caches averaging about two bushels, but not uncommonly reaching 8 to 12 bushels, of cones).

C. Richardson[65] (Large quantities of cones were sometimes taken from squirrel hoards in Ontario, the largest ever reported being 16 bushels).

D. Forbes[66] (As many as 40 bushels of western white pine cones said to have been found stored in a single spot, presumably by one squirrel).

3. Relation of birds and mammals to artificial reforestation by planting.

(1). Nurseries and field plantations for reforestation purposes are often subject to the destructive effects of certain rodents and birds.

A. Peavy in Toumey[67] (In southern California 4,000 knob-cone and Coulter pine plants were destroyed by rabbits in ten days).

B. Johnson and Cobb[68] (Jack rabbit rated the worst pest in tree planting in the Great Plains region).

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[62] Unpublished manuscript, 1925.
[63] Seeding and Planting (New York, Wiley), pp. 143-145, 1916.
[64] Bull. 475, Prof. Paper, U. S. Dept. Agric., p. 5, 1917.
[65] Journ. Forestry, 23: 304-310, 1925.
[66] Amer. Forests and Forest Life, 32: 12-15, 1926.
[67] Seeding and Planting (New York, Wiley), pp. [181-183], 1916.
[68] U. S. Dept. Agric., Farmers' Bull. 1312, pp. 33, 1923.

C. Show[69] (In northern California rodents seriously damage fall plantations and those made on areas more than three years after burning).

D. Couch[70] (*Aplodontias* and other rodents are a serious factor in affecting the plantings on the great Sol Duc Burn, in the Olympic National Forest, Washington).

E. Jones[71] (Birds and chipmunks most bothersome pests at Savanac Nursery, Montana).

F. Korstian[72] (In the intermountain region "Rodents come next to unfavorable sites in responsibility for plantation failures, being charged with nearly one-fourth of the losses on administrative plantings").

G. Anonymous[73] (35 to 50 per cent of redwoods set out, Mendocino County, California, destroyed by rodents, principally wood rats).

4. Certain birds and mammals work not only on seedlings and young reproduction but also on mature trees.

(1). Fisher[74] (In general game mammals and others, by their eating, biting, trampling, breaking, bending, barking and gnawing activities tend to the stunting of trees, loss of increment, and increased danger from insects, fungi, storms and snow).

(2). Pearson[75] (Squirrels, rabbits, rats, gophers, and porcupines in the southwestern United States are responsible for much damage by gnawing the bark).

(3). Taylor[76] (Abert squirrel work in northern Arizona appears to vary directly with the size of the tree, i. e., the larger the tree the more chance of squirrel work; very rarely the western yellow pine may be killed through excessive defoliation by squirrels. Porcupines often girdle western yellow pines near the top, causing spike-tops, or when the spike-tops break off, stag tops).

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[69] Ecology, 5: 94, 1924.
[70] The Murrelet, 6: 39, 1925.
[71] Journ. Forestry, 23: 635-644, 1925.
[72] Dept. Bull. 1264, U. S. Dept. Agric., p. 42, 1925.
[73] The Survey, (mim. house organ of Biological Survey, U. S. Dept. Agric.), 6: 4, April 30, 1925.
[74] Forest Protection, in Schlick's Manual of Forestry, Vol. IV, p. 84, 1895
[75] Bull. No. 1105, U. S. Dept. Agric., p. 135, 1923.
[76] Unpublished notes.

(4). McAtee[77] (The true sapsuckers, genus *Sphyrapicus*, are known to attack at least 258 trees, shrubs, and vines, of which 32 are sometimes killed and 63 seriously injured).

5. The different methods of brush disposal on timber sales probably influence the rodent population and so affect the success of natural reproduction after cutting.

(1). Brown[78] ("It is probable that the practice of burning the brush and debris resulting from logging destroys a very large percentage of the smaller mammals in the forest, though not as completely as do forest fires." The suggestion is made that this is advantageous to the forest, "as these animals destroy no inconsiderable amount of seeds and seedlings . . .").

(2). Of the methods of brush disposal used in the southwestern United States, piling and burning undoubtedly reduces the number of rodents per area, at least temporarily, while scattering, pulling tops, and lopping probably favors their increase.

6. Mammals and birds may often be factors in affecting forest distribution, especially as limiters or destroyers of particular types.

(1). Indigenous wild mammals are sometimes an important factor in preventing the extension of the forest.

A. Fernow[79] (Lists the following animals as tending to prevent the progress of forest growth and to preserve the prairie: locusts, rodents, ruminants, buffalo, antelope, horse).

B. Gifford[80] (Says animals hinder the spread of forests; lists cattle, sheep, camel, giraffe, elephant, moose, bison as among the animal hinderers; attributes treeless condition of Great Plains partly to bison).

C. Wild game, if over-protected so that it becomes abnormally abundant, may become exceedingly destructive to browse and trees and may tend toward the limitation or extirpation of many species.[81]

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[77] Biol. Surv. Bull. 39, pp. 99, 1911; also Biol. Surv. Bull. 43, p. 15, 1913.
[78] Journ. Mammalogy, 4: 196, 1923.
[79] Economics of Forestry, Crowell, New York, pp. 55, 184-185, 1902.
[80] Practical Forestry, Appleton, New York, pp. 87-88, 1906.
[81] See references to Kaibab deer, this paper, page 391.

D. There is at least one case on record of the effective work of a bird in destroying trees.

a. Woodruffe-Peacock[82] (Starlings in England roosted on blackthorns in such numbers as to break down many branches. They took possession of woodpecker holes, causing more holes to be dug, and promoting the entrance of fungous growth. Blackthorns finally cut down to save them from complete destruction by starlings).

(2). Introduced wild mammals are peculiarly likely to become barriers to forest progress and enemies of existing forests.

A. Farrow[83] ("The passing of England from a forest period into a grassland period may of late have been accelerated by the influence of rabbits").

(3). Domestic stock, including cattle, sheep, horses, goats, and hogs, are often highly inimical to forest and tend strongly toward its destruction.

A. Campbell[84] (Cattle or other herbivores on island of Hawaii destroy undergrowth and allow intrusion of Hilo grass, which makes perpetuation of the forest impossible).

B. Pearson[85] (Sheep grazing in the southwestern United States highly inimical to reproduction of western yellow pine; recommends exclusion of sheep from areas which are being restocked).

C. Chevalier[86] (Cattle-grazing [presumably in Europe] prevents the reformation of forest. Pastures often occupy the site of former forests which are prevented from coming back by cattle-grazing and the frequent intervention of man).

D. Buttrick[87] (Under grazing on the royal forests in the British Isles . . . "first the game began to disappear and then the timber").

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82 Journ. Ecology, 6:110-125, 1918.

83 Plant Life on East Anglian Heaths, Cambridge University Press, p. 104 1925.

84 Ecology, 1:264, 1920.

85 Bull. No. 1105, U. S. Dept. Agric., pp. 115-132, 1923.

86 Int. Rev. Science and Practice of Agriculture, n. s. 3:666-671, 1925.

87 Amer. Forests and Forest Life, 32:158, March, 1926.

7. Relation of mammals and birds to forest succession.
   (1). A number of animals, including seed-eating rodents, birds, beavers, etc., are undoubtedly of first importance in primary forest succession. Study of this subject is much needed.
   (2). Certain mammals and birds are undoubtedly important factors in the secondary successions initiated by clear-cutting, fire, water, wind, or insect attack.
      A. Larsen[88] (Emphasizes changes in physical factors of site brought about by cutting; [equally significant changes in the biotic factors of site are undoubtedly produced although not mentioned by Larsen]).
      B. Pulling[89] (Suggests rodents as one cause of faster reproduction of fir than of spruce following lumbering in the northeastern states).
      C. After burning, the mammal population may be temporarily eliminated; birds are perhaps less affected. The relation of animals to the secondary succession following fire is of great importance from the standpoint of reforestation.
         a. Clements[90] (In studies of the life history of lodgepole burn forests in Estes Park, this author reached the tentative conclusion that the real importance of fire was in the removal of rodents for several years. "An understanding of the critical value of the disappearance of rodents is indispensable in explaining the kind and amount of reproduction under various conditions, and especially in working out a method of planting").
         b. Greeley[91] (Thorough poisoning in advance of seeding is necessary except on recent burns where extensive forest fires have done the work of poisoning).
         c. Hofmann[92] (The establishment of even-aged stands of Douglas fir in the Northwest appears to depend in an important way on rodent relations to burns).

[88] Journ. Agric. Research, 28: 1149-1157, 1924.
[89] Journ. Forestry, 22: 813-814, 1924.
[90] Bull. 79, U. S. Dept. Agric., p. 35, 1910.
[91] Proc. Soc. Amer. For., 8: 261-277, 1913.
[92] Ecology, 1: 49-53, 1920.

d. Adams[93] (Birds have a marked influence in hastening reforestation on burned lands in the Adirondacks).

e. Flint[94] (Rodents, presumably mice, did serious damage to seedling trees on a sample plot in a burned area on the Flathead National Forest in Montana).

f. Show[95] ("Rodents seriously damage fall plantations and those made on areas more than three years after burning").

g. Mills[96] (Forest fires have a deadly effect on furbearers).

h. Dice[97] (Changes in mammal habitats in Otsego County, Mich., as a result of clearing and of fires have been very destructive to native mammals. Burned over areas were almost devoid of mammalian life, although no fire had been through some of the areas for 10 years or more, and mammals were abundant in nearby virgin hardwood forest).

i. Wahlenberg[98] (Large burned areas are favorable for direct seeding if planted before rodents learn of presence of seed.

j. Shostakovitch[99] (Forest fires have very destructive effects on wild life in Siberia; mentions birds, bees, mammals, squirrels, ermine, bears, wolves, moose, snakes, wood hen, etc.).

8. Game mammals, game birds, and game fishes, occurring in the forest, are intimately related thereto in an interlocking ecological system, the disturbance of which may and often does have far-reaching effects, both on the forest and on the fish and game. These effects are sometimes beneficial, but they are more often detrimental to the highest use of the area.

(1). Adams[100] (Relations of game to forest constitute a permanent and not a temporary alliance).

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93 Roosevelt Wild Life Bull., 1: 517, 1923.
94 Service Bull., Forest Service, 8: 6-7, 1924 (Dec. 22).
95 Ecology, 5: 94, 1924.
96 Parks and Recreation, 7: 636-638, 1924, not seen.
97 Occ. Papers Mus. Zool. Univ. Mich. No. 159, pp. 3-4, 1925.
98 Journ. Forestry, 23: 594, 1925.
99 Journ. Forestry, 23: 365-371, 1925.
100 Roosevelt Wild Life Bull., 1: 24, 1921.

(2). Grinnell[101] (All living things in forests are interrelated in a far-reaching manner).

(3). The forest normally furnishes food, shelter, and favorable surroundings for reproduction to all game life within it.

(4). The game life affects the forest in which it lives through its relations to the soil (packing; fertilization through excreta and other animal products) and to the biota (affords food for predatory animals, which eat rodent pests of trees; exercises multifarious important effects through consumption of vegetation).

(5). Burning of the forest usually eliminates all fish and game life for a considerable period of time.

(6). Cutting, if extreme, may eliminate much of the game life through excessive modification of physical and biotic factors of surroundings with consequent interference with food and shelter of game. Under certain conditions cutting initiates a secondary succession in which brush and browse figures strongly and which may be more favorable to certain classes of game than the original forest. Cutting may bring about conditions such that certain game species, as the Abert squirrel in Arizona, become detrimental to the remaining forest; i. e., where squirrels are numerous, and the normal number of trees much reduced, squirrel work on trees may become of serious importance where it was not before.

7. Overgrazing by domestic stock may often have a serious effect on fish and game life of the forest. In less extreme instances overgrazing robs the game of shelter and food.[102] The removal of plant cover promotes erosion, flooding, and fish destruction; it also threatens the permanent water-supply of the normal watershed. In extreme cases overgrazing may bring about elimination of the forest. Recall Buttrick's statement, already referred to, that undergrazing in the British Isles ". . . first the game began to disappear and then the timber."[103]

8. In determining highest use it is essential that full account be taken of the recreational and game values involved in the conservation of forest life. Pressure from grazing or lumbering

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[101] Journ. Forestry, 22: 838, 1924.
[102] See Grinnell, Journ. Forestry, 22: 837-845, 1924.
[103] Amer. Forests and Forest Life, 32: 158, March, 1926.

interests should not be allowed to cloud the issue of *de facto* highest use. An impartial scientific inquiry preferably by scientists not concerned with the immediate administrative problems concerned is suggested as a promising method in cases of disagreement or uncertainty. Recreational and game values of particular species should be liberally weighted and balanced against possible damage to the forest by the species in question.

BIRDS AND MAMMALS AND FORAGE PRODUCTION

1. Birds, mammals and reptiles may be either beneficial, or harmful, or both, to forage, including browse, weeds, and grass.

(1). Some instances of damage reported.

A. Rodents generally are estimated to do more than $500,000,000 damage to forage, crops, and stores in the United States.[104] Estimates of damage to forage on the open range total more than $150,000,000.[105] In some of the principal grazing states losses to range from rodents exceed those to crops.

a. Bell[106] (Director of agricultural extension in New Mexico estimates $1,200,000 rodent loss to crops and double this amount to range).

B. Ground squirrels are destructive to forage grasses in many localities.

a. Grinnell and Dixon[107] (Two hundred California ground squirrels estimated to appropriate forage which would keep one steer; 20 squirrels to eat as much as one sheep; in California as a whole, these squirrels estimated to take place of 160,000 cattle or 1,600,000 sheep).

C. Pocket gophers are a factor in reducing range forage in certain localities.

a. Nelson[108] (Pocket gophers seriously reduce forage on some of the most productive grazing lands on the national forests).

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[104] Nelson, Rept. Chief Biol. Surv., U. S. Dept. Agric., Sept. 4, 1919, p. 5.
[105] Bell, Yearbook Separate No. 855, U. S. Dept. Agric., 1920, p. 421, 1921.
[106] Yearbook Separate No. 724, U. S. Dept. Agric. 1917, p. 4, 1918.
[107] Monthly Bull. Calif. State Hort. Comm. Horticulture, 7: 636, 1918.
[108] Rept. Chief Biol. Surv., U. S. Dept. Agric., Sept. 4, 1919, p. 6.

D. The detrimental activities of jack rabbits on range lands are not sufficiently recognized.

a. Taylor and Loftfield[109] (Rodents, chiefly hares, *Lepus alleni,* under experimental conditions on the Santa Rita Range Reserve, Arizona, during the ultra-dry season of June, 1925, consumed 81.5 per cent of the forage grasses—*Bouteloua rothrockii, Aristida divaricata, Aristida californica*—as compared with none consumed under total protection from jack rabbits and stock, and with 100 per cent, approximately, consumed where open to rodents and stock).

E. Prairie dogs are widespread range pests over an enormous area in the western United States.

a. Taylor and Loftfield[110] (As experimentally observed on the Coconino National Forest, Arizona, over a four-year period, prairie dogs destroyed 69 per cent of the wheat grass—*Agropyron smithii*—and 99 per cent of the dropseed—*Sporobolus cryptandrus*—or 80 per cent of the total potential annual production of grass forage. Similar fenced experiments on the Tusayan National Forest over a one-year period showed a destruction by prairie dogs of 83 per cent of the blue grama—*Bouteloua gracilis*).

F. During seasons of drouth the banner-tailed kangaroo rat in certain parts of the Southwest may be of critical importance in relation to forage production and carrying capacity.

a. Vorhies and Taylor[111] (Estimated 64,000 banner-tailed kangaroo rats—*Dipodomys spectabilis*—on the Santa Rita Range Reserve in southern Arizona. Each kangaroo rat might easily consume an average of four pounds of grass seeds and crowns during the season, a total for the Reserve of 256,000 pounds or 128 tons of edible forage).

G. Where grass and browse-feeding rodents are present on an overgrazed range the area deteriorates so much the

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[109] Carnegie Inst. Wash. Yearbook No. 24, pp. 338-339, 1925.

[110] U. S. Dept. Agric., Dept. Bull. No. 1227, pp. 1-15, 1924.

[111] U. S. Dept. Agric., Bull. No. 1091, p. 37, 1922: Journ. Mammalogy, 5: 144, 1924.

more rapidly. The soil tends to become ever more subject to destructive erosion, which, if unchecked, may result in gullying, flooding, and soil removal, an end-result from which recovery is possible only after a slow soil-building process requiring many thousands of years.

H. Birds are well-known to consume and destroy much grass-seed as well as weed-seed. They also consume some seeds of browse.

a. Barrows[112] (Armies of sparrows, finches and similar birds in winter eat and destroy tons of grass seed and weed-seed).

b. Sayle[113] (As already cited, this author finds that seeds of apple, grape, strawberry, and cherry are destroyed by passing through the alimentary tract of pigeons).

I. Certain reptiles consume vegetation on the grazing ranges.[114]

(2). Some possible benefits of birds, mammals, and reptiles on the grazing range.

A. Birds and mammals are important as disseminators of browse. Their relation to the dissemination of grass is probably also close and important.

a. Barrows[115] (Birds are one of the agencies of forest rotation and in resurfacing with vegetation tracts swept bare by wind, water, fire or the hand of man).

b. Forbush[116] (Birds destroy the fruit but plant the seed, being instrumental in extending the woodlands and thickets in which they dwell).

B. As in the forest, so on the grazing range, burrowing rodents, such as pocket gophers, kangaroo rats, and ground squirrels, may serve a useful purpose in cultivating the soil.

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[112] Rept. for 1890, Chief Div. Ornith. and Mamm., U. S. Dept. Agric., 1891, p. 281.

[113] The Auk, 41 : 474-475, 1924.

[114] Van Denburgh, Occ. Papers Calif. Acad. Sci., X, Vol. 1, pp. 77, 91, etc., 1922.

[115] Rept. for 1890, Chief Div. Ornith. and Mamm., U. S. Dept. Agric., 1891, pp. 280-285.

[116] Useful Birds and Their Protection, Mass. State Board of Agric., 1907, p. 93.

a. Seton[117] (As previously noted, this author suggests the gophers of Manitoba are a substitute for earthworms as regards soil-making).

b. Nelson[118] (Pocket gophers are constantly bringing the subsoil to the surface and burying humus, their work often being of the most beneficial character).

c. Vorhies and Taylor[119] (Where abundant, banner-tailed kangaroo rats may be a factor in increasing soil porosity and fertility, for in course of time they probably have succeeded in plowing and cultivating the whole surface layer of the soil).

d. Grinnell[120] ("On wild land the burrowing rodent is one of the necessary factors in the system of natural well-being").

e. The hair, feathers, excreta, bones, and bodies of the animal population undoubtedly play a part in soil fertilization and enrichment. In a region where there is little humus at best this part may be of considerable importance.

C. A host of birds and doubtless some amphibians, reptiles, and mammals are more or less beneficial to forage plants by reason of their insectivorous habits.

a. Gillette[121] (Insects formed 46 per cent of the contents of 22 stomachs of the thirteen-lined spermophile examined, such injurious forms as web-worms, cut worms, and grasshoppers being included).

b. Bailey[122] (The thirteen-lined spermophile of the middle United States feeds especially on grasshoppers, beetles, caterpillars, and ants; more than half of the total contents of eighty stomachs was insects).

c. Bailey[123] (Grasshopper mice are so widely distributed that they serve as an effective check on the increase of certain insects).

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117 "Agr. Rep. Mam. for 1882, pub. Winnipeg, 1883, pp. 169-172," not seen; also Life Histories of Northern Animals, Vol. I, pp. 578-586, 1909.

118 Nat. Geog. Mag., May, 1918, p. 502.

119 Bull. No. 1091, U. S. Dept. Agric., p. 33, 1922.

120 Journ. Mammalogy, 4: 149, 1923.

121 Bull. Iowa Exp. Sta., No. 6, p. 42, 1889, not seen.

122 U. S. Dept. Agric., Biol. Surv. Bull. No. 4, p. 43, 1893.

123 U. S. Dept. Agric., Farmers' Bull. 335, p. 14, 1908.

d. Van Denburgh[124] (Many lizards in the range country are of insectivorous habit).

e. Burnett and McCampbell[125] (Prairie dogs in Montezuma County, Colorado, found to eat cutworms, beetles, and carabid larvae).

D. Carnivorous mammals, birds, and reptiles promote forage growth by feeding on rodent pests. Coyotes, badgers, skunks, and foxes are among the mammals involved; hawks and owls among the birds; the Gila monster, at least, among the reptiles; and the rattlesnake, gopher snake, and certain others among the *Serpentes.*

2. Relation of birds and mammals to distribution of grass and browse.

(1). Wherever they are numerous, such rodents as hares, rabbits, and prairie dogs undoubtedly add an appreciable effect to the work of game or domestic stock in limiting or eliminating the more palatable species of vegetation and permitting the growth of those which are less desirable.

A. Farrow[126] (Work of rabbits in East Anglia largely determines the distribution of pinewood, *Calluna* heath, *Carex arenaria,* and dwarf grass-heath).

(2). The maintenance of the short grass plains and of some of the turf grasses generally in place of tall grasses is probably due principally to overgrazing by stock and rodents. In certain localities where grazing by stock originally depleted the range the effects of rodents alone are sufficient to prevent recovery.

A. Clements[127] (Overgrazing, in the western great plains region of the United States, favors *Boutelous* and *Bulbilis* at the expense of *Stipa* and *Agropyron.* Pure short grass cover partly if not largely a response to grazing animals; short grass plains a recent modification of mixed prairie due to overgrazing. "Of the first and the most direct importance are the relicts produced by

[124] Occ. Papers Calif. Acad. Sci., X, Vol. 1, 1922, pp. 112-114, 124, 137, 163, 208, 285, 475, 503, etc.

[125] Colo. Agric. College, Circular 49, p. 9, January 1926.

[126] Plant Life on East Anglian Heaths, 1925.

[127] Carnegie Inst. Wash., Pub. 290, p. 116, 1920; Pub. 355, p. 7, 1924.

overgrazing and by rodents, since these factors have operated directly upon the normal climax.").

B. Taylor and Loftfield[128] (*Bouteloua gracilis*, in Coconino Wash in Northern Arizona, is favored by prairie dog grazing pressure at the expense of the bunch grasses, *Agropyron smithii* and *Sporobolus cryptandrus*).

C. Farrow[129] (In East Anglia dwarf grass-heath, composed principally of *Festuca ovina* and *Agrostis vulgaris*, ". . . owes its very existence to an extremely injurious influence [i.e. rabbit grazing] which nevertheless greatly benefits it because it injures its competitor slightly more.").

(3). In certain localities browsing, grazing, seed-eating, root cutting or girdling of reproduction of coniferous or other woods by wild animals undoubtedly tends to favor the extension of grazing range at the expense of forest, this effect usually being added to the work along the same line of domestic stock. The principal wild offenders are probably rabbits and hares, porcupines, wood rats and other rats, certain squirrels, and deer and other game mammals.

(4). There are some notable instances of the direct spread of plants by wild mammals or birds.

A. In the Southwest wild birds and mammals together with domestic stock assist the spread of the mesquite (*Prosopis velutina*); wood rats help to disseminate the cholla cactus (*Opuntia fulgida*, and others); and a number of mammals in the fur of which the seeds may find lodgment help to scatter the alfilaria (*Erodium sp.*).

B. Gaurrodger[130] (When conditions are favorable emus in Australia increase, consume much pasturage of cattle, destroy wire fences, and spread prickly pear cactus).

3. Animals and ecologic succession on the grazing range.

(1). Birds, mammals and reptiles, not to mention insects, undoubtedly have much to do with primary successions on the range.

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128 Unpublished notes.
129 Plant Life on East Anglian Heaths, pp. 10, 24, 1925.
130 The Emu, 25; part 2, October, 1925, not seen.

(2). The higher vertebrates as well as the insects are probably of even greater economic importance in the secondary successions initiated by overgrazing than in the primary successions. Proper regulation of the wild animal population of an area may in some cases be basic to the successful revegetation of the range.

4. Game animals on the range constitute a special problem full of complications but of unusual importance.

(1). Overgrazing, by removing the food and shelter of game, promotes game exhaustion directly as the forage is depleted.

A. Grinnell[131] (The effect of grazing by livestock in reduction of vegetation which serves as food and shelter for game is the prime cause of game scarcity in the national forests of California).

B. Alaskan, anonymous[132] (Rabbits in Kenai Peninsula eat same food as moose—willows, beech twigs and leaves, alder brush, aquatic plants, etc.; fifty per cent of moose calves of 1922 said to have perished in snow from starvation as a result of rabbits eating their food).

(2). In estimates of carrying capacity and in making grazing allotments full account should be taken of the game animals on each area; our game on the grazing ranges of the Southwest includes the bighorn sheep, American antelope or pronghorn, black-tail or mule deer, (turtle) doves, and several species of quail—Gambel quail, fool quail, scaled quail.

5. The relation of animals to erosion.

(1). Jones[133] ("Overgrazing is responsible for much more abnormal erosion than all other causes combined."). Since rodents, especially, are often heavy eaters of soil-binding vegetation, it has come to pass that wherever overgrazing has developed rodents have often become auxiliaries in the pervasive and destructive erosion which is so widespread throughout the range country, being particularly obvious in the southwestern United States. Some of the ultimate possible effects of excessive run-off, which, of course, may occur

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[131] Journ. Forestry, 22: 841, 1924.
[132] Amer. Forestry, 29: 719-720, 750, 1923.
[133] Southwestern District, U. S. Forest Service, p. 6, Dec. 1923.

either in the forest or on the grazing range if the vegetation cover is removed by overgrazing by stock or rodents or both are suggested by Lowdermilk[134] (Run-off on non-forested as contrasted with forested slopes in Shansi, northern China, were as 57 to 1 on one set of plots, and as 78 to 1 on three other sets of two plots; in some cases for single storms the contrast was as high as 1,505 to 1; author discusses theory that excess of run-off, by carrying to sea large quantities of water which should be held in region by evaporation, ultimately reduces total rainfall, contributing to dessication and depopulation).

(2). The protection of beavers on thinly timbered streams is cited by Jones as one of the causes of erosion in the Southwest.

(3). Rodent effects are of serious importance on the heavily overgrazed watershed tributary to the Salt River Valley storage project at Roosevelt Lake on the Tonto National Forest, Arizona. Evidences of severe rodent work were encountered in September, 1926, both in the upper and lower basins. The soil-binding vegetation has been largely depleted, and the siltage of the Roosevelt Reservoir is correspondingly augmented. There is a question whether rodent effects alone would not prevent range recovery in this section even if stock were removed.

(4). The effects of the same burrowing rodents may be beneficial in some places and detrimental in others.

A. Nelson[135] (Pocket gophers, as already mentioned, are beneficial over an enormous area, but on bare slopes their work is highly injurious).

6. Animal populations are often subject to seasonal and cyclical variations in numbers and activities. The importance of this principle is easily appreciated in the southwestern United States, where there is extraordinary daily, seasonal, and secular variation in climatic conditions, with all that is implied in terms of environmental factors such as temperature, water, plant life, including bacterial and fungous diseases, and animal life, the latter obviously including human life and welfare.

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[134] See Chapman, review of Lowdermilk's paper, Journ. Forestry 24: 697-698, 1926.

[135] Nat. Geog. Mag., May 1918, p. 502.

(1). The forage-consuming propensities of rodents may ordinarily be of little moment in the favorable portions of "normal" years, i.e., years of average rainfall or better, but at the time of greatest stress, e. g., during seasons or years of great aridity they may become important. In years of deficient rainfall rodent effects may be harmful throughout a considerable period. Their most serious effects, in a given year, are registered in the driest season; in a cycle of years, in the driest portion of it; the most damaging effects of all are noticeable in the driest seasons of the driest years.

A. Grinnell and Dixon[136] (California ground squirrels, *Citellus beecheyi,* probably compete closely with cattle in extra dry years only).

B. Vorhies and Taylor[137] (Banner-tailed kangaroo rats, *Dipodomys spectabilis,* may be of critical importance on grazing areas during periods of extreme drouth).

(2). The control of animal populations is at least to some extent mediated by disease, of which examples are given. Man is susceptible to all the diseases mentioned except, possibly, the plague-like disease of rats discovered by Dr. McCoy.

A. Wyman[138] (For thousands of years rats and mice have been recognized as connected with pestilences and plagues).

B. Blue[139] (Refers to Rudenko's suggestion of the possibility of the tarbagan, in Siberia, carrying plague; also refers to the occurrence of plague in the California ground squirrel).

C. McCoy[140] (In addition to the true plague, reports on a second plague-like disease in the California ground squirrel).

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[136] Monthly Bull. Calif. State Comm. Horticulture 7: 636, 1918.

[137] U. S. Dept. Agric., Bull. No. 1091, p. 37, 1922; Journ. Mammalogy 5: 144, 1924.

[138] The rat and its relation to the public health, Public Health and Marine-Hospital Service of the United States, pp. 9-14, 1910.

[139] Rodents in relation to the transmission of bubonic plague, in the same work, p. 150.

[140] U. S. Public Health Bull. No. 43, p. 53, 1911.

D. Henshaw and Birdseye[141] (Rodents and other mammals harbor the ticks believed to be chiefly responsible for the spread of spotted fever, which was peculiarly virulent in Bitter Root Valley, Montana).

E. Henshaw[142] (Emergency appropriation passed by Congress of the United States, March 4, 1916, providing for the suppression of rabies, which had alarmingly increased among wild animals, particularly coyotes, in southeastern Oregon, northeastern California, northern Nevada, and southwestern Idaho).

F. Nelson[143] (Rabies spread by coyotes, dogs, and bobcats through Washington, Oregon, Idaho, northern California, Nevada and western Utah).

G. Elton[144] (The Mongolian marmot, or tarbagan, *Arctomys bobac,* appears to be a reservoir of infection of pneumonic plague in Asia).

H. Francis[145] (Rabbits, hares, and certain ground squirrels of the United States are subject to an epidemic disease known as tularemia).

I. Elton[146] (Maximum numbers of mice, chiefly *Microtus hirsutus,* and appearance of epidemics of plague in a limited district in England occur with such regularity that it is even possible to predict them).

CONCLUDING OBSERVATIONS

(1). The problems of forest, forage, wild game, etc., are parts of the inclusive problem of effective production of useful plants and animals which constitutes agriculture in a broad sense. We can only maintain our standard of living by a proper solution of these problems.

(2). Interrelationships between the plants, animals, and their surroundings are almost infinite in their complexity. An adequate research program in forest and forage production must provide for thoroughgoing studies of *all the predominant organisms in the biota, as well as of their environment.*

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141 U. S. Dept. Agric., Biol. Surv., Circ. No. 82, p. 3, 1911.

142 Rept. Chief Biol. Surv., U. S. Dept. Agric., Aug. 31, 1916, p. 2.

143 Rept. Chief Biol. Surv., U. S. Dept. Agric., Sept. 14, 1922, p. 7 and the same for Sept. 18, 1924, p. 8.

144 Journ. Hygiene, 24: 138-163, 1925.

145 Journ. Amer. Med. Assn. 84: 1243-1250, 1925.

146 Letter, unpublished.

(3). The place of birds, mammals and other vertebrates in the communities of the forest and the grazing range is one of superlative importance. Not only the game species are significant, but the insectivorous birds, the burrowing rodents, the plant-destroying species, etc. In some instances the very existence of the forest and of certain valuable forage species is dependent on proper regulation of vertebrate populations.

(4). The maintenance of adequate forest and forage production in the United States is a task of unusual present and future difficulty. Each of us has a direct and personal interest in the matter. We humans are enmeshed in nature's great web along with all the other organisms. Unlike most of them, however, we can to a considerable degree adjust the net to our present and future welfare. For better or for worse, our children and our children's children will be affected in a far-reaching way by policies we employ today.

(5). The only possible hope for coming through with the balance on the right side of the ledger is based on research. The trial and error, or "fumble and success," method, has been tried for five hundred thousand years or more, without conspicuous success. "The price of progress is research, which alone assures security of dividends."

(6). Traditional education is a broken reed. It must be replaced by a vigorous and progressive process which will enlighten the people as to the value of research, inspire their vastly increased support of it, and stimulate the prompt and thoroughgoing application of attested results.*

* Two works of outstanding significance dealing with subjects here considered have just come to hand. One, a short paper by Munns, very pertinently inquires, Where is the forest biologist? (Journ. Forestry 24: 911-914, December, 1926) and shows how much more inclusive forest biology is than study of game alone, all forms of wild life being involved and each playing an important part. The other, A National Program of Forest Research (Pub. by Amer. Tree Assn. for Soc. Amer. Foresters, pp. lx + 232, 1926) by Clapp, Hall, Hastings, and collaborators, is notable for its recognition of the unity and complexity of the forest problem, the place of biology with the other sciences in it, and the overwhelming need for more research.

INFLUENCE OF PRECIPITATION CYCLES ON FORESTRY*

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I. INTRODUCTION

There is a good deal of similarity between agreement among scientists, at least in the early stages of their work, and an Idaho cloudburst in July. That is, both are apt to be rather rare. Therefore, it is quite significant that noted ecologists are in almost complete accord in recognizing some relation between the radial growth of trees and precipitation. It is true that on moist sites sunlight, temperature, or some other factor may be the controlling element in tree growth, and rainfall in decreasing sunlight may actually have a deleterious effect. But in the preponderance of forest conditions in this country a positive precipitation-growth relationship probably exists.

With such surprising unanimity among ecologists, it seems strange that foresters for the most part have neglected this clue to past climate. For there are numerous ways in which a knowledge of ancient rainfall would help the woodsman. The silviculturist derives most of his ideas for cutting from a study of past results, but rarely considers that a changing climate may render his present conclusions worthless. The mensurationist invariably assumes that future increment will be similar to that which has occurred, without remembering that the tables he has founded on growth rates of the past may be completely altered by different weather in the future. And the western fire fighter, battling with what Colonel Greeley has termed "the most difficult task of protection that any forest organization ever tackled in the history of the world,"[1] may derive considerable encouragement if he finds that his hardships have been caused by an unusually dry phase of the climatic cycle, while on the other hand, if it has been a relatively wet phase—Oh well, there are plenty of stones to tie around one's neck, and plenty of rivers handy.

In northern Idaho, where silviculture, forest mensuration, and fire fighting all reach their climax for the Northern Rocky Mountain region, there are no precipitation data going back more than 45 years. Consequently, it seemed desirable to extend these meager records through an analysis of tree growth. White pine was chosen as the species to be

* Paper read before the Northern Rocky Mountain Section, Society of American Foresters, February 7, 1927.

analyzed for two reasons. First, it has fairly high moisture requirements, and consequently can be expected to reflect a scarcity of precipitation more readily than a drouth-resistant species. Second, the white pines which reach maturity, due to their relative intolerance of shade, have generally been dominant throughout life. Thus the effect of suppression is eliminated.

The stands selected for study were all situated on well drained sites, where there was no excess of water to make an abnormal rainfall superfluous. They were located in the Priest River watershed of the Kaniksu National Forest. The data were all obtained from the stumps of recently cut trees.

One precaution was essential in selecting the stands, and that was to have as wide a dispersion in age as possible. If only a single age class were chosen, one could not be sure that the variations in growth were due to meteorological differences, and not merely to the naturally divergent increment of youth and age. However, if four or five different age classes all indicated an increase or a decrease, it would furnish a very strong basis for presuming that a climatic effect was being manifest in the growth.

The present investigation has included five age classes: 280, 230, 180, 140, and 75 years old. In each of these groups from 8 to 15 dominant trees were measured. This number is well in excess of the five trees which Douglass (2) has set as a minimum for obtaining satisfactory records in this type of work.

II. DATA AND COMMENTS

A. Meteorological Points Brought Out by the Growth Curves

In Figure 1 the pentadel or five-year growth is plotted for each age class. These irregular graphs are smoothed in Figure 2 by the use of a five pentad moving mean. By this method general trends stand out much clearer than they do in the first diagram.

Even a most cursory examination of Figure 2 reveals one outstanding point. In every age class from the veteran 280-year-old stand to the youthful 75-year-old stand which normally should be experiencing its most vigorous increment, there is a rapid decrease in growth during the past forty years. This is so distinct as to preclude any possibility of mere chance being the cause. Suppression could not have been responsible because the trees studied were ones which from their size must have been dominants, or in youth even superdominants. Disease, too, may be eliminated from consideration. Therefore, the only possible

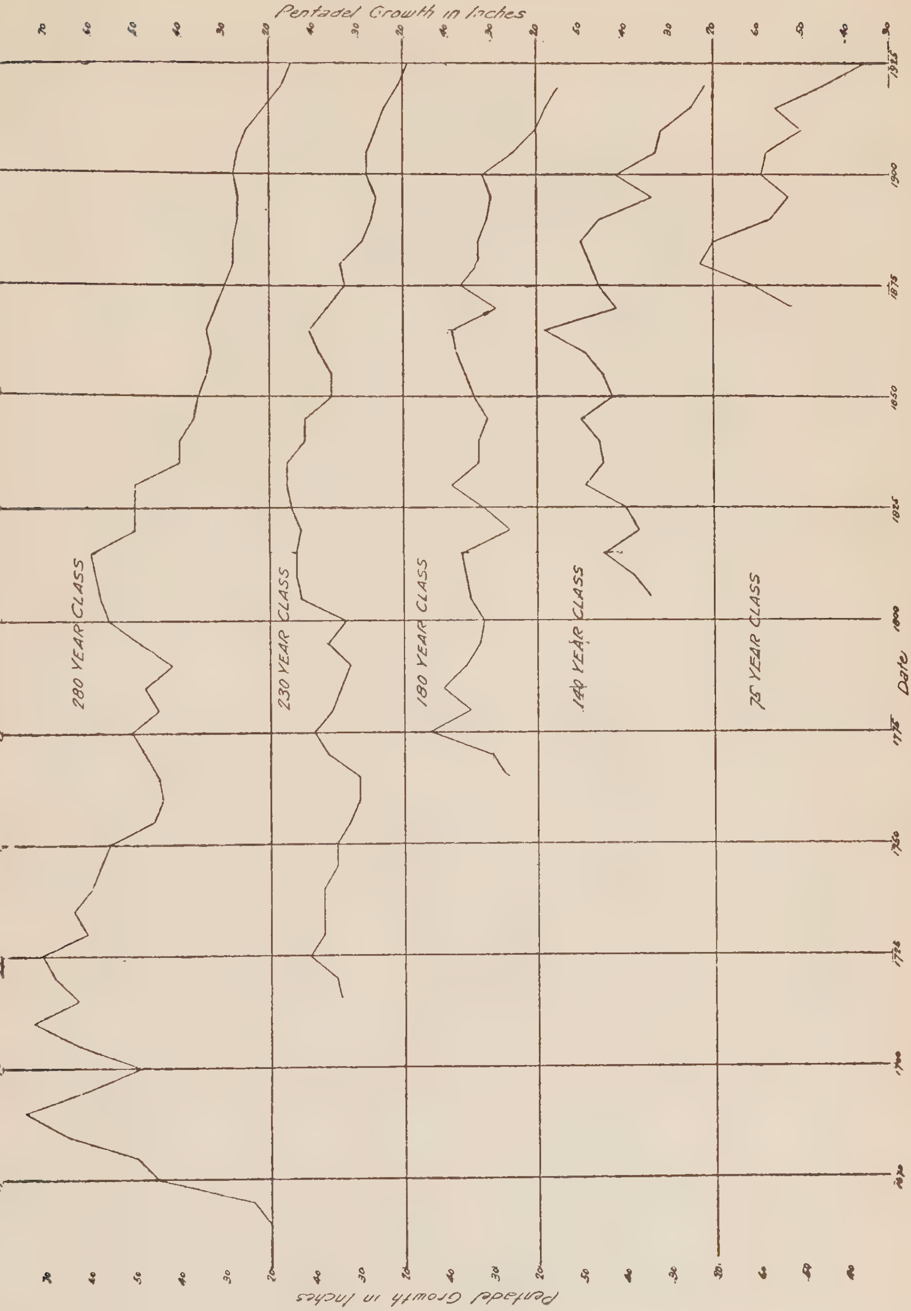

Figure 1
WHITE PINE GROWTH 1675-1925
Unsmoothed

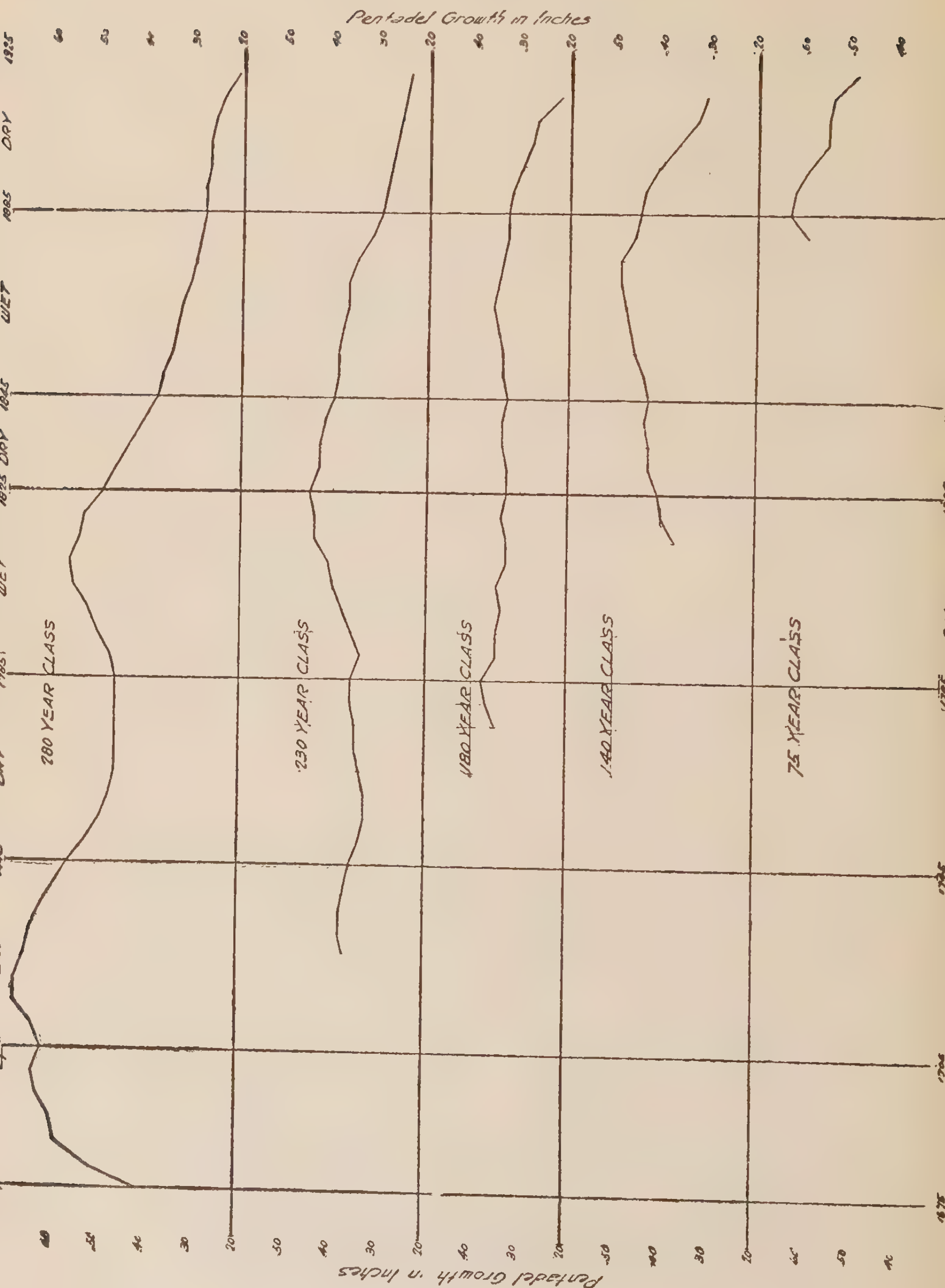

Figure 2
WHITE PINE GROWTH 1675-1925
Smoothed

solution seems to lie in a deficiency of precipitation. This deficit not only seems certain, but also appears to be unprecedented in the 250-year period covered by these growth curves.

Less obvious, but apparent on closer analysis, is the indication of distinct wet and dry periods, as shown in Figure 2. No attempt has been made to draw well-defined boundaries around them, but instead general periods of a relatively retarded or accelerated growth have been segregated, each covering at least 20 years.

The forty years since 1885 have obviously formed an exceedingly dry epoch, with every age class slumping badly in growth. The forty previous years, however, at first glance would seem to bear conflicting evidence. The three younger groups all reach peaks during this period, but the older ones both slump. However, this is what one would expect with stands which averaged respectively 220 and 170 years of age. The significant point is that both show the slowest depreciation during these four decades of any period during their unbroken retrogression of senility. Thus, instead of invalidating the evidence of the younger age classes, they actually augment it in indicating a wet phase of the climatic cycle.

The evidence bearing on the score of years between 1825 and 1845 also appears muddled at first glance. The 280-year class shows an exceptionally rapid decline, while the 180-year class reaches the trough of its first 140 years of growth. The 140-year class shows a slow acceleration, but relatively this can be considered a decided drop, for normally the period between 40 and 60 years should show the most rapid growth rate. Only the 230-year class is inconsistent, for it practically maintains its growth peak. Nevertheless, the vote seems to be 3 to 1 that this was a dry period.

Between 1785 and 1825 the 280-year class exhibits a remarkable peak, almost incredible in a stand which was already 140 years old. This certainly indicates an abundance of precipitation in a striking manner, as does also the next younger group, which after 50 years of poor growth, at the age of 95 started a rapid acceleration which lasted for 35 years. Only the 180-year class causes scientific sorrow, for no 40-year-old stand should slump, no matter how slightly, during wet years. But here again the majority should prevail, pending further investigation, and so this 40-year period should be called a wet one on the basis of the growth records.

At this point it seems necessary to digress in order to anticipate any scornful inquiries as to whether the author has ever heard of fire,

insects, or wind opening up stands and thus causing marked acceleration in growth. He has. Nevertheless, these particular stands were not thinned by such "acts of Providence." This is proven amply by the character of the acceleration, which is very gradual, in contrast to the rapid increase typical of suddenly opened stands. In regard to fire, there is the additional fact that none of these thin-barked pines show the slightest trace of scars.

Going back from 140 to 180 years ago, only two age classes remain. Both of these indicate clearly a dry period. The older drops rapidly, and then maintains the lowest level of its first 180 years. The younger, just when it should be making its best growth, also reaches the low point of its first 180 years.

In regard to the forty years before this period, we have only the oldest age class to fall back upon. This reaches a peak, as one would expect for a stand of 60 to 100 years, and we can only surmise from its unusual height, exceeding all other points on any of the curves, that this was due to a wet phase of the cycle coming in conjunction with the most vigorous period of youth.

Table 1 sums up the evidence which these growth curves give in regard to the climate for the past 220 years.

TABLE NO. 1

Climatic Periods in Northern Idaho

Wet	Dry
1706-1745	1746-1785
1786-1825	1826-1845
1846-1885	1886-1925

In Figure 2 only general growth trends are discernible, because all extreme peaks or depressions have been ironed out by the use of a five pentad moving mean. We must turn to Figure 1 if we wish to discover individual pentads of maximum growth. Here coincident peaks are found in all curves for the five-year periods ending in 1725, 1775, 1815, 1865, and 1900. The unanimity in each case is striking, for there is not a single curve which fails to show these peaks.

B. Checks of Growth Evidence.

Although, as previously mentioned, growth is generally recognized as a fairly reliable index of precipitation, it would be well to make use

of any other information which might either substantiate or refute the previous conclusions. Three additional sources of data seem to be potentially useful.

1. The Spokane weather records.
2. The distribution of age classes in northern Idaho.
3. Historical references to climate or forest fires.

1. Spokane Weather Records.

Of the meteorological stations, the records of which go back 30 years or more, Spokane is nearest to the Kaniksu National Forest. It has recorded rainfall continuously since 1881, which permits a check of growth dating back nine pentads. The precipitation figures for this station are shown in Table 2.

TABLE 2

Spokane Precipitation Records

Pentad	Mean Annual Precipitation	Precipitation Smoothed by 5 Pentad Moving Mean
1881-1885	20.45	.....
1886-1890	16.90	.....
1891-1895	17.35	18.08
1896-1900	19.21	17.15
1901-1905	16.48	16.84
1906-1910	15.79	15.91
1911-1915	15.37	14.66
1916-1920	12.72	.....
1921-1925	12.95	.....

The only marked peak indicated by the unsmoothed precipitation records occurred between 1896 and 1900. During those five years the mean annual rainfall averaged 1.86 inches higher than during any other pentad in the past 40 years. This one peak is perfectly reflected by the growth record, which also shows its one definite acceleration between 1896 and 1900. If the precipitation records are smoothed by a moving mean, the same unbroken drop that was found in every growth curve is at once apparent. It can therefore be stated that during the past 40 years growth and precipitation trends have been nearly identical.

In contrast to this close correlation with precipitation, it was impossible to find any connection between the tree growth and the Spokane temperature fluctuations.

2. Age Class Distribution

The inception of a new stand in the white pine region is almost always dependent on the wiping out of the old stand by fire. Despite

the varying activity of the causative agencies, it is reasonable to assume that forest fires are more extensive in dry than in wet times. Therefore, it follows logically that more stands should have started in dry than in wet periods. Consequently, if we find out in what periods the greatest area of present stands started, we will have another indication of past climate. Fortunately there are fairly complete age class records for the region in which the growth study was made, including the Kaniksu, Coeur d'Alene, and St. Joe National Forests. These have been kindly furnished by Koch, who first suggested this method of studying past climate. (3). They are shown in Table 3.

Table No. 3

Age Class Distribution on Kaniksu, Coeur d'Alene and St. Joe National Forests

Age Class	Area in Acres	Per Cent of Entire Area
0-20	373,799	35
21-40	102,175	9
41-60	54,860	5
61-80	58,066	5
81-100	110,666	10
101-120	43,194	4
121-140	22,224	2
141-160	126,409	12
161-200	51,764	5
200+	138,333	13
Total	1,081,490	100

From these figures it is at once possible to divide the age classes in two well-defined groups: those which embrace five per cent or less of all the stands, and those which include nine per cent or more. In the former group the following age classes are found: 41-80; 101-140; and 161-200. In the latter occur age classes 1-40; 81-100; and 141-160. Dating these groups to their years of inception, the periods of rare and common origin of stands are shown in Table 4.

Table No. 4

Origin of Stands in Northern Idaho

Relatively Few Stands Originating	Relatively Many Stands Originating
1726-1765	1766-1785
1786-1825	1826-1845
1846-1885	1886-1925

Comparing Table No. 4 with Table No. 1, a remarkable coincidence is noted. With one partial exception the periods of rare origin are identical with those which apparently were wet, while the same is true of the periods of common origin and those which were dry. If the assumption made at the beginning of this section is valid, then age class distribution certainly furnishes a very strong check of the climatic characteristics indicated by the study of growth.

Before leaving this subject it is only fair to mention the weaknesses of age class distribution as an indicator of precipitation. These may be included under three general headings:

1. The younger age classes show a disproportionately large area because they have not had the same opportunity to be reburned that the older ones have had. It is probable that a considerable share of the 35 per cent of the forest originating in the past 20 years was previously included in the age classes from 21 to 200. The older the stand the greater has been the opportunity of being destroyed. Thus the figures presented do not give an accurate conception of the total area burned over in each period, but they do bring out distinct tendencies.

2. The determinations of age in the different stands are not entirely accurate. Nevertheless, in general they seem to give results sufficiently close for use in studying approximate and not finely divided periods. Furthermore, the errors are at least partially compensating.

3. The age classes have been grouped into 20-year periods, which are unlikely to correspond exactly with climatic cycles. An age class might fall half in a wet period and half in a dry period, and show negative results.

3. *Historical References.*

The early explorers of the Northern Rocky Mountain region necessarily wrote about forest fires from a purely subjective standpoint. It was always a case of one man's impression of a single forest fire, never a broad view of the general forest fire situation. Thus Kolecki in 1859 and DeSmet in 1863 gave graphic accounts of their experiences with individual forest fires. But fires occurred every summer, and it was merely a matter of chance that brought men who recorded their experiences into the woods in these specific years.

Captain Bonneville's vivid description of the fires in northeastern Oregon in 1834, however, does indicate a more general occurrence of conflagrations than do any of the other early writings. We find in Washington Irving's "Bonneville" such phrases as: "Here they found

all the plains and valleys wrapped in one vast conflagration. . . . The great conflagration of the country, which had harrassed the main party in its march, was still more awful, the farther this exploring party proceeded. . . . In daytime the mountains were wrapped in smoke so dense and blinding that the explorers, if by chance they separated, could only find each other by shouting." This account would suggest that 1834 was a rather severe fire year, and this is substantiated by both the growth curves and the age class records.

In 1805 Lewis and Clark kept detailed records of the weather. During the months of June, July, and August, while passing through north central and southwestern Montana, they encountered no less than 32 rainy days, whereas for the past 30 years the average for this region has been around 20. On July 7 Captain Clark wrote: "Cloudy as usual." The next year on June 25 the Indians were cheerfully setting fire to the woods along the Lolo Trail in order to bring fair weather, a pastime which would scarcely be considered rational in the Twentieth Century. During their two summers among the mountains neither of the intrepid captains reported a single forest fire, although they saw numerous signs of former ones. All this evidence corroborates the conclusion previously drawn that 1805 belonged to a wet period.

C. Irregularity of Radial Growth.

Probably most foresters have a picture in their minds of a curve which typifies the trend of growth in the normal tree. This tree starts slowly, but the increment soon rises rapidly. At 40 to 80 years the culmination is reached, and thereafter the growth falls off, until at extreme age it is practically negligible. The question naturally arises how much this normal trend is affected by precipitation. To determine this point the five growth curves depicted in Figure 2 have been plotted by age instead of by date. They are shown in Figure 3.

It does not take long to see from this figure that the good old normal growth curve is a delusion. The 280-year stand alone shows that rapid rise which is supposed to be typical of youth. The 140-year class increases slowly, which is not so far wrong, but the other three violate all orthodox principles of growth by actually decreasing, the youngest age class with sensational rapidity. After 100 years, when growth is certainly supposed to decline, it does in two cases, but most emphatically does not in two others. At 165 years, when any self-respecting tree should be sinking steadily into the stagnation of senility, one stand is found to reach a sensational second growth peak.

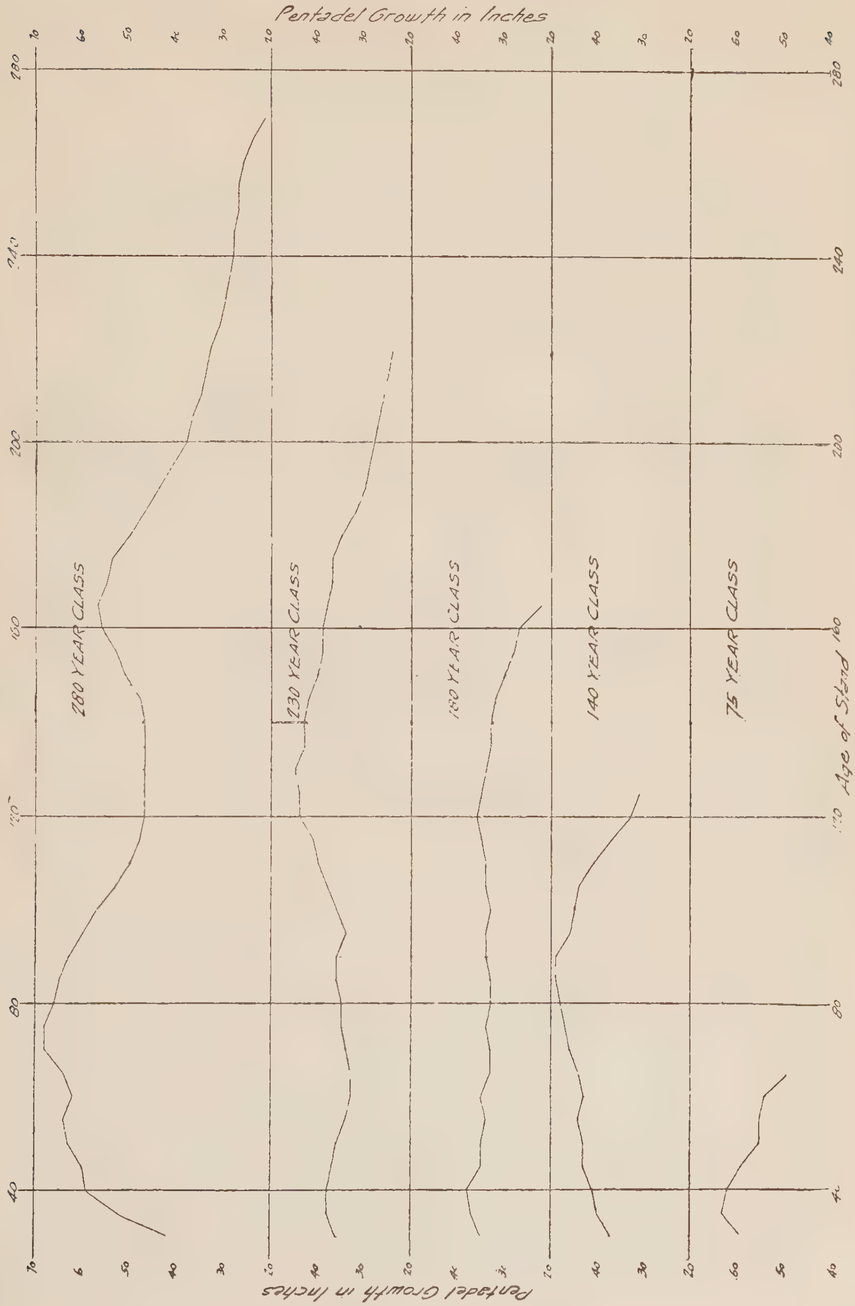

Figure 3
WHITE PINE GROWTH BY AGE

It appears, therefore, that any idea of a normal growth trend in a region of marked climatic variations must be modified. The natural tendency of the tree still exists, but it is frequently swamped by the more powerful effect of precipitation.

III. APPLICATION TO FORESTRY

It now remains to consider what possible bearing these precipitation cycles may have on the practice of forestry. This subject will be discussed under three heads: fire protection; management; and growth and yield.

A. Fire Protection.

Koch (3) has already suggested that the severe present-day fire situation may be due to an unusually dry period. This study bears out his contention very strongly. In fact I would go farther than that, on the basis of the data already presented, and say that the twenty years since the Forest Service was created have been the driest score of years in two and one-half centuries. If that is correct it makes the protection outlook a little more hopeful. No permanent changes in climate have yet been found in the United States (4), and so it is reasonable to predict that the present downward trend in precipitation will eventually be reversed. The break may come during this present pentad, or it may be 10 or 15 years hence; nobody can prophesy with any degree of accuracy. But when it does come we may hope for several decades, like the periods from 1706 to 1745, 1786 to 1825, and 1846 to 1885, in which there will be no continual, plaguing fear of another 1910 or 1919 or 1926.

B. Management.

Most of the sale areas in the western white pine type leave seed trees for regenerative purposes, and if possible for a future cut. In theory the trees which are left are supposed to show a greatly accelerated growth, due to the removal of competitors for light and soil moisture. As a matter of fact this increase has often proved very disappointing. But the timber sales in northern Idaho have all been made during the present period of extreme drouth. Consequently the beneficial effect of release could easily have been offset by the unfavorable climatic conditions. In certain cases cutting might actually have exercised a retarding influence on the reserved trees, through the additional soil desiccation contingent upon opening the stand. Therefore, it seems

fair to assume that the failure of seed trees to show satisfactory growth during the present abnormal period is no criterion of what they will do in more favorable years. If the seed tree method causes small increases in growth today, twenty years from now the results may be highly gratifying.

The same principle applies to thinnings. This has been well illustrated on the Priest River experimental forest, where even the heaviest of thinnings made in 1914 have given disappointing results. On the surface it seemed that either none of the cuttings was severe enough, or that western white pine was not responsive to liberation. But the intensity of a thinning which was largely a failure in that exceedingly dry decade between 1914 and 1924, might well prove a great success during some moister period.

The forester can modify his methods in several other respects to meet the exigencies of the different phases of the climatic cycle. When management becomes more intensive, he can reserve his dry south slopes, on which reproduction is obtained with great difficulty at the present time, for cutting during wet periods. He can establish a somewhat flexible annual cut, so that the greatest amount of logging will occur in the moist years, which favor the establishment of reproduction.

D. S. Olson, chief of planting in District 1 of the U. S. Forest Service, says: "There have been no wet summers in a long time, but on steep north slopes the moisture conditions are comparable to those found generally in wet years. Here, in 1925 for example, nearly 100 per cent survival was attained, whereas on the dry, sunny aspects less than 60 per cent of the trees planted survived." With this in mind, it might be possible to reserve the most severe sites for planting during wet epochs. The volume of planting, too, could oscillate in harmony with the general trends of the climatic cycle.

C. Growth and Yield.

With increment as irregular as it is shown to be in Figure 3, it seems obvious that certain reservations are necessary in accepting the results of growth and yield studies. Trees are frequently bored to determine how rapidly they have grown during the past two or three decades, and the results obtained are then projected into the future to determine the size of the trees 20 or 30 years hence. But if the borings were made in wood laid down in dry years, and the future prophecy should apply to wet years, the results will obviously be much in error.

In all the textbook methods, and occasionally in actual practice, annual cut for uneven-aged stands is calculated largely on the basis of current annual increment. But if current annual increment is constantly changing, grave errors will surely be introduced when figures obtained under one set of growth conditions are applied to an entirely different set of conditions.

Yield tables are made by measuring the volume of stands as they have grown in the past. But there is no guarantee of, indeed the chances seem to be very much against, a repetition of the same growth conditions. We want to know what volume a stand reproducing today will have in 2027, and so we measure today the growth in stands which reproduced in 1827. The results we obtain will be accurate only in the remote event that the two centuries should prove to be climatically similar.

An interesting illustration of this idea may be found in the growth of the 140- and 180-year age classes. These two stands were located on adjacent and partially overlapping sites, which to all appearances were identical in quality. The 180-year stand, however, started at the beginning of the dry period of 1745-1785, and during its first 100 years experienced but 40 years of the wet phase of the climatic cycle. The 140-year stand, on the other hand, had its inception at the beginning of the moist period of 1785-1825, and enjoyed 80 wet years out of its first 100. At the end of a century the dominant trees in the latter stand had an average stump height diameter of 15.9 inches. In contrast to this the average diameter of the 180-year dominants, which had experienced but half as much abnormally moist weather, was only 12.2 inches. Thus the occurrence of a rainier century appears to have made one age class grow 30 per cent faster than the other in stump height diameter.

The most common method of determining site is by height growth. A forester entering a 40-year stand on the Kaniksu might assume from the heights of the trees that it was growing on Site III. However, if the next 40 years should prove to be abnormally wet, the growth might well become so rapid that measurements at 80 years would throw this stand into Site II. Thus any calculations of yield based on a site quality III would go awry.

Larsen and Haig's 1924 white pine yield tables indicate that 45 per cent of the cubic foot volume of a 160-year-old stand is laid down between 40 and 80 years of age, while only 26 per cent occurs during the first 40 years. This is probably due largely to the normal growth

habits of trees, but it certainly seems logical to assume that some of this big difference was caused by the effect of precipitation. The 80-year-old stands on which this table was based lived through both the dry and wet phase of the climatic cycle, but the career of the 40-year-old stands was spent entirely in the dry phase. Had a yield table been made in 1884, following four moist decades, it is safe to say that a considerably higher volume would have been obtained for the first 40 years.

IV. SUMMARY

Briefly summarized, the following have been the most important points which this paper has tried to show:

1. The climate of northern Idaho has exhibited distinct wet and dry periods, varying in length from 20 to 40 or more years.
2. The 20 years since the Forest Service was created appear to have been the driest score of years in two and one-half centuries.
3. The occurrence of such varying amounts of precipitation has a vital and often neglected bearing on the practice of forestry.

CITATIONS

1. Greeley, W. B. 1926. A message from the chief. The Bulletin, Northern District, U. S. F. S.: Oct., 1926.
2. Douglass, A. E. 1919. Climatic cycles and tree growth. Carnegie Institution. Publication No. 289, pp. 21-22.
3. Koch, Elers. 1925. The periodicity of burns as determined by age classes of existing stands. The Bulletin, Northern District, U. S. F. S.: April, 1925.
4. Marvin, Charles F. 1923. Concerning normals, secular trends and climatic changes. Monthly Weather Review: 1923. pp. 383-390.

FOREST POLICY ON INDIAN TIMBERLANDS

By J. P. Kinney
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I am not authorized to state the past motives of my superiors in the Interior Department nor to announce what the purpose of the Department may be in the future. All that I can do is to set forth the principles upon which I have acted in the past and upon which I expect to act in the future and to say that so far as I am aware these principles are in full accord with the general purposes of those who have the final decision on "Forest Policy" in the Indian Service. I feel that my interpretation of past policy and my estimate of future policy should be accorded a reasonable amount of weight. While I waive credit for much of the excellent forestry work that has been done on Indian lands, I do claim credit for outlining and directing the general policies; nor do I shirk responsibility for a large part of the failures to accomplish the ideal in forest practice. Under the general supervision of the Commissioner of Indian Affairs, for the greater part of seventeen years I have directed the forest activities of the Indian Service and in such a position I have had ample opportunity to influence, if not shape, the policy of the Service; and I am happily able to say that, generally speaking, throughout that whole period I have found the attitude of my superiors friendly to the principles of forest conservation.

At the outset it must be recognized that the problem on Indian lands is essentially different from that on National Forest lands. The status of the latter has been definitely fixed as National Forests and to be administered for the benefit of the general public. On such lands the expenditure of large sums for permanent improvements, the reservation of merchantable timber for known, or speculative, future uses, the investment of substantial sums in reforestation or afforestation projects will almost certainly meet with public approval, and there is little chance that the value of such improvements to the owner—the public—will be lost through a change in the status of the land.

Indian lands are principally in a status analogous to private ownership, and yet under decisions of the Supreme Court of the United States the status of such lands may be modified at almost any time by an act of Congress. Furthermore, there have been court decisions holding that lands which the Indian Service considers primarily valuable

for the production of timber crops may be selected by individual Indians for allotment purposes and thus become subject to private ownership irrespective of any policy or purpose of the Interior Department to hold such lands for timber production purposes.

These conditions inject an element of uncertainty into the problem that can hardly fail to shake the resolution of any forester who desires that land primarily adapted to the growth of timber crops shall be handled with that one purpose in view, with the reservation of such portion of the existing merchantable stand or the expenditure of such sums on permanent improvement, reforestation, afforestation, and even fire protection, as may seem necessary to the achievement of the desired result. . . . The fact is that the Indian question is one that seems to have baffled all branches of the Federal government, and while numerous state functionaries have been very outspoken with respect to the incapacity of Federal officials and the impotence of the Congress to deal with the question, no state has, I believe, distinguished itself in efforts toward a solution.

As early as 1911, I, personally, prepared and urged legislation directed to the establishment of conditions under which the Indian Service could give to Indian lands, primarily valuable for timber production, a fixed status; but the proposed legislation was never submitted to Congress because of a feeling on the part of those, who probably understood conditions far better than I, that such legislation could not be obtained. I do know that since that time Indian lands that should have been reserved for forest production and slope protection purposes—notably on the Flathead, Colville and Quinaielt Reservations—have passed into private ownership. Yet much as I deplore this improper and uneconomic use of forest land I doubt if anyone would be justified in the suggestion that any one or any number of persons in the Interior Department could have prevented this unfortunate tendency toward dispersion of title.

Those of you who passed through the earlier period of administration of the National Forests know how persistent was the pressure between 1905 and 1918 for the acquirement of private interest in lands lying within the boundaries of National Forests. Just as these land-hungry adventurers sought homesteads and mining claims within National Forests, so did they surge about the borders of Indian reservations, whetting their land appetites on various morsels of misinformation with respect to the fortunes lying dormant—yea, indeed, "locked-up"—within the illogical and arbitrary boundaries of Indian reserva-

tions. It was this misdirected enthusiasm for the acquisition of homesteads and other "claims" within Indian reservations that resulted in the years of wasted time and energy of which hundreds of abandoned shacks and fairly well constructed houses now scattered over the Flathead and Colville Reservations give mute but impressive testimony. Since the year 1920 there has been no urgent demand from whites for homesteads within reservations, but the attractive prices at which timber has been sold on Indian lands in recent years has thoroughly aroused the acquisitive instincts of individual Indians who now seek to acquire individual title to timber resources that have heretofore been considered tribal property. Obviously the successful practice of forestry on lands held in small tracts as individual allotments is now, and ever will be, exceedingly difficult. It is because of the impossibility of maintaining good forest practice on tracts of minutely divided ownership, that I and my associates in the Indian Service have considered it necessary to adopt a cutting policy that is often widely divergent from the theoretically correct forest management policy.

On Indian reservations such as those in Minnesota, Wisconsin, Idaho and Montana, where large areas of timberland have been allotted, we have felt that the only sound policy was to cut practically all trees of saw-timber size; and in many instances the tie timber, mining stulls, cedar posts, and pulp have been removed. When the land is agricultural in character and there is any prospect that it will soon be used for the growing of crops, this is unquestionably a sound policy. Timberlands with a soil well adapted for agriculture were allotted on all reservations in Wisconsin, except Menomonie, on all except the Red Lake Reservation in Minnesota, on the Coeur d'Alene and Nez Perce in Idaho, on the Flathead in Montana, on the Tulalip in Washington, and to some extent on various other reservations. It must be admitted that many of the allotments well suited for agriculture have not been cleared after timber operations and frequently—more especially in the last three years—I have had serious doubts as to the wisdom of clear-cutting even on Indian lands well adapted for agriculture.* The almost complete cessation of land clearing and farm development on logged-over lands in Minnesota, Wisconsin, and more westerly states in recent years, has caused me to question seriously the wisdom of the practice that we have been following on allotments for fifteen years. Whatever faults there may have been in our administration of timber affairs,

*It must be admitted that even agricultural land already farmed has been abandoned during the past five years.—Editor.

have been in loose practice rather than in theory for on page 11 of the first "Instructions for Officers in Charge of Forests on Indian Reservations," approved on June 29, 1911, and still in effect, I wrote under the head of "Allotments":

"Upon areas not adapted to agriculture, where because of the slope a forest covering is needed, where the leaving of a second crop of timber is desirable, where the permanent maintenance of a woodlot is essential, and where any other conditions demand it, the merchantable trees necessary to accomplish the end in view should be reserved from sale. Extensive clear cutting should be permitted only where the land will be utilized for agricultural purposes."

I have never abandoned the principles embodied therein, and I believe our whole forestry force in the Indian Service have clung steadfastly to that ideal, but the difficulties of selective cutting and the importunities of allottees have possibly at times swerved us too much from our course.

Section seven of the act of June 25, 1910 (36 Stat., L. 855-57, enacted subsequent to my entry of the Indian Service), was the first legislation authorizing timber sales upon Indian tribal lands generally. A previous act of February 16, 1889 (25 Stat., L. 673), had provided for the sale of dead timber, but the act of 1910 authorized the sale of "mature, living and dead and down timber on unallotted lands of any Indian reservation." It will be noted that this legislation clearly contemplated a conservative cutting and the policy of the Indian Service has always been in accord with the provisions of this legislation.

However, it has been assumed that it was the intention of the Congress to accord considerable latitude to the Department of the Interior in the carrying out of the purpose of this act, since the act provided that the Secretary should prescribe regulations to govern operations and made it clear that the primary object of such legislation was to insure to the Indians occupying each reservation the beneficial use of the forests thereon. All sales made under authority of this act have contemplated the cutting of the timber in such manner as to insure the maintenance of the forest cover on all lands primarily adapted to the production of timber crops.

On many reservations a large part of the standing merchantable timber was mature or over-mature and the removal of all mature timber would leave little reproduction or advance growth. On areas of this character it has been the policy to leave a part of the mature timber for seed trees. Where there is a mixed stand of mature and immature

trees of yellow pine, or mixed types, in the yellow pine region, a true selective cutting has been made. In the Douglas fir, cedar, spruce and hemlock type of western Washington we have generally followed the policy of cutting all mature trees and, as all who are familiar with these coast types know, very few trees of any species remain uninjured when the logging is completed.

What I have said as to a general policy of selective cutting east of the Cascades should probably be further explained. The policy has never been rigidly fixed as to the whole West or even as to any particular districts in the West. The conditions are quite variable on reservations both in the Northwest and the Southwest. On the Colville in Washington we have fairly satisfactory reproduction conditions coupled with most extreme fire danger; on the adjoining Spokane we have fully as good reproduction factors with materially lower fire risk and with a much larger percentage of the timber land included within allotments; on a large part of the Klamath we have little reproduction or advance growth associated with over-mature stands, and on the Flathead the saw timber has been reserved for the tribe on tens of thousands of acres for which individual Indians have been given trust patents. Obviously our policy must be modified to fit the conditions on the different reservations and even on different parts of the same reservation. On the Mescalero and Fort Apache Reservations in the Southwest, where we have excellent conditions for western yellow pine reproduction and quite generally fair advance growth on tribal lands, we are justified in reserving a fair stand of vigorous young or middle aged trees; but on the Jicarilla where practically all timber land is allotted and the beneficial interest of the tribe in the timber will expire in 1932, the removal of the greater part of the mature timber is clearly indicated.

But possibly I am stepping over into the field of practice in directing attention to these varying conditions that demand flexibility in the carrying out of a policy. The general policy of the Forest Branch of the Indian Service may be stated as follows:

1. To administer all allotted timber lands so as to insure the highest present economic return consistent with a reasonable consideration of the future use to which the land will probably be devoted;

2. To administer all tribal lands that are primarily adapted to the production of timber, or the protection of slopes, in such manner as to secure the highest present economic return for the tribe that is consistent with theoretically correct forestry principles and to preserve

these lands so that whether they remain permanently as communal lands of a tribe, are acquired by the Federal or state government, or are sold in large areas to private interests, they shall remain productive and capable of doing their part toward insuring the future welfare of the citizens of the United States of which the Indians themselves are a part.

This general policy in forest fire protection, timber sale activities, and general administration, has guided the efforts of the Forestry Branch of the Indian Service for sixteen years. The men in charge of the forest work on various reservations have been given a large measure of initiative and responsibility with the result that there has been rather wide divergence in the application of the policy, but I think mistakes that have occurred are possibly no more serious than might have resulted from an enforced uniformity of application.

Because of the over-mature condition of the merchantable stand of timber on most Indian reservations and the need of funds for individual assistance and for the support of enterprises for tribal benefit, large quantities of timber have been sold in the last ten years. These sales have not all been made on a theoretically sound basis from the forestry viewpoint. On some reservations, having large timber resources, only small sales of stumpage, or even none, have been made and on others a larger amount than the needs of the Indians' demand has been sold. The matter of utilization must depend to some extent upon the market and other practical considerations. The Forestry Branch of the Indian Service has sometimes succeeded in arousing interest in units of timber that should be sold, sometimes it has failed; on the other hand, timber has occasionally been offered primarily because there was a strong demand from one or more operators that such timber be placed on the market, and when there was no reason to think that the interest of the Indians would be injured by such offering. The Service has on several occasions declined to place particular units of timber upon the market where considered inadvisable.

Generally speaking, the quantity of timber on Indian lands in any particular locality does not constitute such a proportion of the whole amount of timber in the region that the Indian Service would be able to control production on a sustained yield basis. However, this problem has been studied and in a few instances a sustained yield policy has been definitely announced. Thus the offering of another large tract of timber on the Colville Reservation for a number of years has been decided to be inadvisable, and on the Klamath Reservation several

requests for the offering of large units have been denied within the past two years. On the Klamath small units have been offered in the past year to meet an insistent demand from local operators, having large investments to a considerable extent dependent upon reservation stumpage, and to clean up scattered tracts in portions of the reservation that had been logged or were under contract. It is the purpose to hold the annual cut on the Klamath to approximately 200,000,000 feet board measure. At this rate the amount of timber on the reservation will afford about a thirty-year cut; sufficient timber on cut-over areas will be left to insure a sustained yield of from 50,000,000 to 100,000,000 feet yearly. All logging operations on the Klamath are selective; an average of 2,500 feet board measure above 12 inches in diameter is left and on many areas up to 5,000.

The Klamath situation is not paralleled on any other reservation, but on all reservations having a large area of tribal timberland, attention is being given to the regulation of cut with a view to making the forest on the reservation contribute its part toward the ultimate establishment of a sustained annual yield for that particular district. However, carrying out such a general policy must take into consideration the present over-mature timber, the present needs of the Indians, and to a certain extent, the desire of the Indians themselves, for it must be remembered that the Indian Service, as a trustee, is administering these lands primarily for the benefit of the owners.

A LABORATORY STUDY OF BLACK SPRUCE

By P. A. Herbert
Forest Taxation Inquiry, Forest Service

When the forester waxes enthusiastic concerning the possibilities of forestry on the out of the way corners of the farm, the chances are that the farmer will direct his attention to yonder bog meadow and want to know whether he . . . "can grow one of 'them' tree crops you're talking about there!" The forester will have to beat a hasty, and none too graceful retreat, murmuring something about toxic conditions, poor aeration, etc., preventing most tree species from growing there, and those that will grow there often being difficult to get started and then growing very slowly when they do gain a foothold.

Experiences like the above led the writer to formulate a plan of fundamental research in which detailed and precise studies were to be made of swamp species under controlled conditions, and to be accompanied by similar studies of various swamps in an effort to correlate the plant requirements and adaptations to the actual environmental conditions found in the different swamps, *i.e.,* a study in plant anatomy, physiology, and ecology. Ultimately, the factor, or group of factors that limit the species to be found in swamps, and that retard their growth might be measured and possible steps taken either to improve the environment or to breed trees to adapt themselves more effectively to the swamp conditions as they are. The writer had hoped to make a slight impression on this problem in studies to have been carried on for a doctorate over a period of seven years, but a change in position necessitated the dropping of the study for the time being just as the work was being started.

The first problem naturally to be given consideration was the preparation of a bibliography, and while many interesting hours already have been spent on it, much literature must still be examined before it is brought up to date. At the same time a few trial experiments chosen more or less at random from among the many to be undertaken, were set up. The remainder of this paper will deal with these.

After several fruitless attempts the seed of one swamp species was secured, that of *Picea mariana,* black spruce. This seed was collected at the Dunbar Forest Experiment Station of the Michigan State College located along St. Mary's River south of Sault Ste. Marie. Much of this seed came from old cones found clinging to the limbs many years after ripening and which may account for the fact that the number of seeds per pound (over 500,000) in this lot was far greater than previously recorded counts. It may also explain the low germination, that of 20 per cent. The germination period was fourteen days.

However, if the seed had been tested in an earth medium as is usually done this period would have been slightly extended and the total per cent of germination lowered. The seeds were germinated and grown in a moist chamber in which had been placed the lower part of a moist chamber of slightly smaller dimensions. Over the inner glass container a piece of coarse muslin was stretched, the edges of which were long enough to reach to the bottom of the chamber. The whole apparatus was then placed in an electric sterilizer over night. In the morning, seed treated in the usual way with formaldehyde and then thoroughly washed with sterile water was placed in the moist chamber on the muslin. Enough sterile water was added to bring the surface of the water about one quarter of an inch below the surface of the muslin. The chamber was then closed and kept closed until germination ceased. Its progress could be watched through the cover and no bacterial or fungus growth marred the study. These seedlings at the end of three weeks had tops averaging 12 mm. and roots of 25 mm. They were used in the experiments that follow save for the first series.

A study was undertaken to determine the physiological balance of black spruce in nutrient media. It is well known that certain definite ratios between the necessary inorganic salts should be maintained in soil and water cultures. Toxic calcium can, for instance, be made non-toxic by the addition of small amounts of magnesium. The technic used in this and the succeeding experiment was that developed by Dr. R. P. Hibbard of the Botany Department of Michigan State College under whose direction this work was done. The method follows generally those evolved by Tottingham (1) and Shive (2).

A total concentration of 1.00 atmosphere was employed and the following proportions based on an 84 point schematic equilateral triangle used:

TABLE I

Composition of the Several Solutions

Number of Points	KH_2PO_4*	$Ca(NO_3)_2$*	$MgSO_4$*	H_2O
11	14cc	10.4cc	160cc	1000cc
15	14	52	80	1000
18	14	81.2	20	1000
21	28	10.4	140	1000
23	28	31.2	100	1000
33	42	31.2	80	1000
44	56	41.6	40	1000
45	56	52	20	1000
51	72	10.4	80	1000
52	72	20.8	60	1000
62	86	20.8	40	1000
81	114	10.4	20	1000

*One quarter molecular solutions.

The first series set was for purposes of trying out the technic, and as black spruce seedlings were not then available, *P. excelsa* 2-0 stock was used. A number of interesting secondary observations were made. The buds, for instance, burst in about two weeks, although no root growth was discernible until the fourth week. New root development invariably took place between 3 c. and 7 c. below the root collar, although the old root systems averaged 18 c. in length. These plants received the usual care in lifting and heeling-in, and so possibly, this may indicate that the removal of the lower part of the root system would not seriously retard their later development.

The amount of cultural media absorbed depended upon the weather conditions and the amount of leaf surface. Thus, the average rate of absorption was only 12 c.c. during the first week before the new buds burst and 142 c.c. during the fifth week when the plants had acquired 115 mgr. of new needle growth. Allowing for increased transpiration due to imperfect temperature and humidity control in the greenhouse as the season advanced, the plants absorbed approximately one centimeter of solution for each milligram of new top growth. The root growth only bulked 20 per cent as heavy as the top growth.

P. mariana seedlings two weeks old were placed in a similar series of solutions and in seventy days' growing time, despite the apparently inherent slow growth of the species, gave the following results:

TABLE 2

Growth of P. Mariana in Solutions with Varying Amounts of the Same Salts

No.	Top Development		Root Development			
	Length	Weight	Tap Root	Side Roots		Weight
				No.	Length	
11	23mm	2 mg	53mm	1	10mm	1.5mg
15	25	1	36	1	10	.7
18	20	1	25	0	0	.6
21	18	.7	58	2	10	.4
23	19	2.5	70	3	15	1.3
33	26	5.0	85	4	10	5.0
44	30	4.0	60	2	30	3.0
45	27	3.7	65	4	15	4.0
51	24	2.4	32	2	10	.6
52	27	1.0	75	1	10	.5
62	21	3.2	30	1	15	1.1
81	28	2.0	35	3	20	1.0

From the above table it can be seen that in solution number 33 the plants weighed seven times as much as they did in number 15 or 18. Solution 33 is apparently near the optimum for black spruce. The length of the top or the root does not seem to be as reliable a criterion as weight.

These results seem to fit in fairly closely with those obtained in the test series with *P. excelsa* and may indicate that there is a similarity in physiological balance between these two species. As additional contemplated series were not set up to check these results, no conclusions are warranted although the general agreement with the other series would seem to indicate that an excessive concentration of any one salt with small amounts of the other essential salts is unfavorable, and that the best ratio is a medium KH_2PO_4 and a low $MgSO_4$ with a medium amount of $Ca(NO_3)_2$.

Before the above experiment to determine physiological balance had been completed, three series of tests to determine the importance of the several necessary elements to the growth of *P. mariana* were set up. The total concentration used was 1.0 atmosphere as in the previous experiment, and the proportion of essential salts being similar to culture number 52. It was thought at the time that this culture might be one of the best, which expectation was, however, not borne out.

The results obtained from these three series are listed in the following averaged table:

TABLE 3

Growth of P. Mariana in Different Chemical Solutions

Solution	Top Development		Root Development				Remarks
	Length	Weight	Tap Root	Side Roots No.	Side Roots Length	Weight mg	
Tap water....	27mm	3.0mg	86mm	2	20mm	2.0	Dark roots
Distilled......	25	2.2	110	3	10	2.1	Light roots
Complete.....	27	1.0	48	2	10	.8	Poor
—Fe.......	28	3.1	93	4	18	2.5	Good
—N........	28	2.8	82	3	20	1.0	Fair
—Mg......	25	3.5	36	3	10	1.5	Poor
—P........	26	3.5	65	1	15	2.0	Good
—Ca.......	25	2.5	70	3	25	2.0	Good
—K........	28	3.9	33	2	10	1.5	Poor
—S........	23	1.8	30	0	0	.7	All dead

The preceding table shows conflicting results as did the individual series. The complete nutrient solution made next to the poorest showing on the basis of weight. It will be noticed that almost identical results were obtained from a similar solution (No. 52) in the previous experiment.

This experiment will have to be repeated in order to determine whether any mistake in measurements was made either in the preparation of the solutions or in the results. If not, it will indicate that physiological balance is an important factor in the growth of *P. mariana* seedlings, but that the lack of any nutrient element save sulphur and nitrogen has little effect on the development of the seedling during its early life, or that a sufficient amount of each element is carried within the seed for the period of three months covered by these tests.

Another test undertaken was to place 200 *P. mariana* seeds in various cultural media and by treating all sets alike, to determine the differences that can be attributed to the media during the period of germination and subsequent growth. The following table summarizes the observations made:

TABLE 4

Growth of P. Mariana in Different Media

Media	Germination			Damping Off	Top Development		Root Development	
	%	Days First	Total Days		Length	Weight	Length	Weight
Water.........	22	7	11	None	22mm	2.8mg	85mm	2.0mg
Loam.........	14	9	20	25%	18	1.5	30	1.0
Muck.........	19	9	20	80	25	3.3	45	1.8
Fine Sand.....	26	8	18	2	20	2.5	55	1.9
Sphagnum.....	7	12	25	5	20	3.0	50	1.6
Coarse Sand...	19	9	15	None	0	...	..	...
Clay..........	11	10	60	None	0	...	..	...

From this compilation it can be seen that tap water used in moist chambers as previously described is the best media for studying germination and seedling growth, with fine sand a close second.

The last test tried was to determine the effect of freezing on the viability of the seed. No change in germination was noted in seed frozen for 48 hours just previous to being placed in the greenhouse, but seed first subjected to optimum conditions for germination for 48 hours and then allowed to freeze for 24 hours had a germination per cent of only two as compared to the check with 14 per cent.

REFERENCES

1. Tottingham, W. E. A quantitative chemical and physiological study of nutrient solutions for plant cultures. In Physiological Researches, 1 : 4 : 33-246, May, 1914.
2. Shive, J. W. A study of physiological balance in nutrient media. In Physiological Researches 1 : 7 : 327-297, November, 1915.

MORE ABOUT GROWTH PER CENT

By E. J. Hanzlik
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The article "A New Growth Per Cent Formula" by Gevorkiantz, in the January, 1927, issue of the Journal of Forestry, introducing the formula $P = \frac{228}{n} x \frac{D-d}{d}$, was of special interest in that it is a decided improvement over the other methods in arriving at the volume growth per cent directly from the diameters. The relationship between the basal area per cent and the volume growth per cent has not heretofore been presented except through the graphic method as used by the writer in the western yellow pine region of Oregon during the last two years,[1] and by Sven Petrini of the Swedish Forest Experimental Station.[2] The methods of presentation in these two cases are identical, being in the form of one curve showing the basal area increment per cent, and another curve showing the volume increment per cents, at various ages, obtained from the same tree measurements.

The Gevorkiantz formula is simply the expression of this relationship between these two curves numerically in place of graphically, and thereby gives the volume growth per cent directly from only one computation, this formula being especially desirable because of its simplicity and ease of calculation. I would suggest, however, one change in its final form, namely, that the number *228* be omitted and the letter F (factor) be substituted, for it appears to me that this will vary according to the species and the unit of volume, such as whether cubic or board measure is used. Therefore, in its final form, it would be written $P = \frac{F}{n} x \frac{D-d}{d}$ where D is the present diameter at breast height, d the diameter *n* years ago, and P = the average growth per cent per annum for *n* years.

In order to check the value of this formula for western yellow pine in Oregon, the volume growth per cents for three series of age-diameter-board foot volume measurements were used, namely, for the Blue Mountains region (Site IV), the Looking Glass Creek data (Site III),

[1] The Growth Per Cent Method of Predicting Future Volumes; The Univ. of Washington Forest Quarterly, Feb. 1927.

[2] Tillväxtprocentens Beräknande (The Calculation of the Increment Per Cent with the Method of Compound Interest). Bulletin of the Swedish Forest Exp. Station, Vol. 22, No. 4, 1925.

and the Klamath data (Sites I and II).[3] First, the board foot volume growth per cent was computed by 10-year periods from the age-volume data by the compound interest method. These per cents, (not curved) were then considered as a standard from which a factor, F, was calculated by transposing the formula, $P = \frac{F}{n} x \frac{D-d}{d}$ into $F = \frac{P x d x n}{D-d}$.

Thus for each 10-year age-class, from 80 to 300 years for the Looking Glass data, and 80 to 420 years for the other two, a factor was obtained. Inspection showed no regular differences as the trees grew older, rather they tended toward a common average for each set of figures. Averaging each series separately, there were obtained the following factors:—

Blue Mountains 292.9
Looking Glass 297.2
Klamath 295.0

A weighted average of the above gave a value of 296.0 as an average factor for these three localities in the yellow pine region in Oregon.

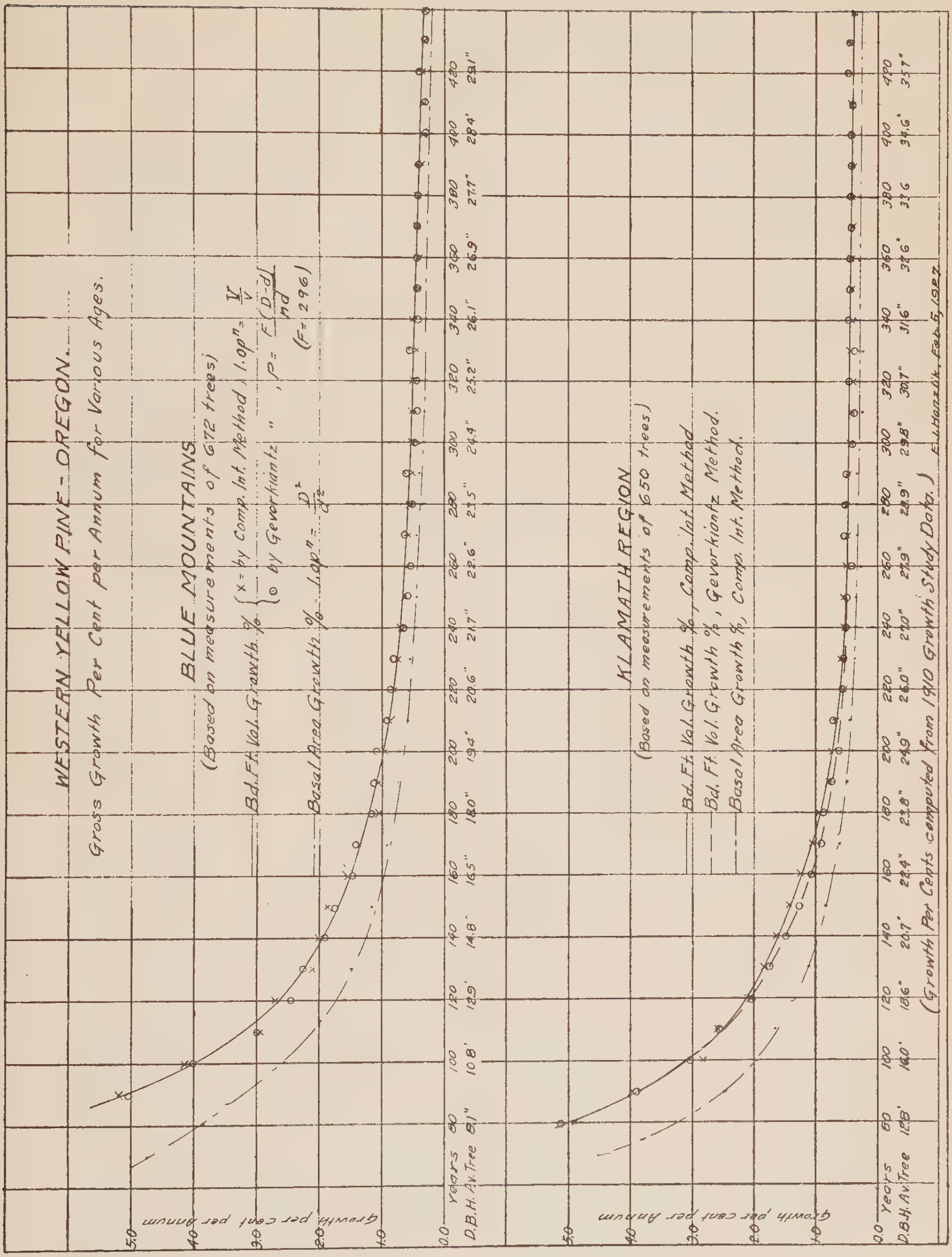
As a check of the growth per cent obtained by the new formula, using 296 instead of 228, the growth per cent curves were plotted for each series. That is, the board foot growth per cent calculated by the compound interest method was first plotted and a curve drawn through the points. Upon the same base were plotted the growth per cent points obtained by the formula method, and curves drawn through these points also. An inspection of the appended curves shows the striking similarity of the curves attained by these two methods.

The greatest differences in the calculated per cents occur in the regions of better sites for trees between about 100 to 180 years of age, that is, the regions where trees of these ages put on volume proportionately greater than is taken care of by the factor in the formula.

These differences, however, at their maximum are not to be considered excessive when considering the application in the field, where, as a rule, diameters and volumes can not be so accurately determined. Thus, if D and d are 22.4 and 21.6 inches respectively, the calculated average annual growth per cent ($P = \frac{296}{n} x \frac{D-d}{d}$) for a 10-year period is 1.096 per cent; however, if D is the same and a slightly different angle taken by the borer, and d is calculated as 21.5 inches, the resulting figure is 1.238 per cent.

Therefore, it appears as if the degree of accuracy of this formula

[3] Sites are based on the average heights of dominant mature trees—Site II = 151 to 175 ft., Site III = 126 to 150 ft.; Site IV = 101 to 125 ft.


WESTERN YELLOW PINE - OREGON.
Gross Growth Per Cent per Annum for Various Ages.
BLUE MOUNTAINS
(Based on measurements of 672 trees)
Bd. Ft. Vol. Growth %
x = by Comp. Int. Method, 1.op^n = V/v
⊙ by Gevorkiantz " , p = F(D-d)/nd
(F = 296)
Basal Area Growth % 1.op^n = D²/d²
KLAMATH REGION
(Based on measurements of 650 trees)
Bd. Ft. Vol. Growth %, Comp. Int. Method
Bd. Ft. Vol. Growth %, Gevorkiantz Method.
Basal Area Growth %, Comp. Int. Method.
(Growth Per Cents computed from 1910 Growth Study Data.)
Growth per cent per annum
Years
D.B.H. Av. Tree

is far greater than is actually obtainable in the field measurements which are to be used in the calculations, and as a method for field use it is far more accurate than any of the short-cut methods previously used and is less difficult to compute.

There is one point in the discussion which I am tempted to question, i. e., regarding the use of the growth per cent for future volume calculations. This is in the last paragraph on page 49, the first two sentences. Quoting "In applying the figures for growth per cent obtained by this formula to a stand, the use of compound interest tables is recommended. *After the growth per cent (p) is obtained, the value of* $(1.0p)^n$ *is looked up in the tables and the present volume multiplied by this to determine the volume n years hence.*" The gist of my disagreement is in the second sentence, not with the use of the compound interest tables, but with the use of the present growth per cent to be compounded.

Calculations have shown that with increasing age, the growth per cent is constantly decreasing. The appended curves show this decreasing tendency for western yellow pine, and similar data have been presented by Sven Petrini for birch in his work in Sweden.[4] There are undoubtedly certain general trends of this growth per cent, varying possibly for different species, and for the same species upon different sites. The method, therefore, of compounding the *present* growth per cent for a period of years incorrectly presupposes that this per cent is a constant value applied to an annually increasing volume. However, as actually happens, the growth per cent is a decreasing value laid on an annually increasing volume, the decreasing per cent of growth for yellow pine taking the form as shown in the curves. Therefore, the estimated future volume can not be based upon the compounding of the present growth per cent, but must take into consideration this decreasing tendency over a period of years, and an estimated per cent must be used based upon the trend of the curve and the number of years for which the calculation is to be made. This, of course, makes it necessary that growth per cent curves for various species applicable to the region in question are on hand.

As an example of this method of use, let us take the Klamath yellow pine region in a stand about 140-180 years of age. The calculated growth per cent, based upon borings in the field and the formula, $P = \frac{296}{n} \times \frac{D-d}{d}$, is 1.5 per cent per annum. To obtain greater ac-

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[4] Tillväxtprocentens Beräknande. Bulletin of the Swedish Forest Experiment Station, Vol. 22, No. 4, 1925, by Sven Petrini.

curacy in the per cent figure, we can convert this to the true volume growth per cent by finding where the formula method curve (dash line) intersects 1.5 per cent, and by reading directly upward to the actual volume growth per cent curve we get a value of 1.62 as the present growth per cent per annum. For a prediction 20 years hence, this growth per cent drops from 1.62 to 1.23, so that compounding 1.62 per cent for 20 years would give an exceedingly high value. Therefore, using the principle of this decreasing growth per cent, a value at one-half the period should be used, in this instance amounting to 1.42 per cent. The value of 1.42 per cent for a 20-year period is then obtained from the compound interest tables, amounting to 1.326. With a present volume of 5,000 board feet per acre, the estimated future volume at the end of 20 years is then equal to 5,000x1.326, or 6,630 board feet. If a calculation for a longer period is desired, as 60 years, the estimated average annual per cent for this period is read at a point at one-half the period, in this case amounting to 1.05 per cent. The estimated future volume is then 5,000x1.872, or 9,360 board feet. These above calculations result in the gross estimated volume, and deductions must be made for insect losses, windthrow, decay, etc., as necessary for the locality and species, in order to arrive at the estimated future net volume.

YIELD TABLES—HOW MANY PLOTS?

By L. H. Reineke
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An analysis of the relation between accuracy of yield tables and amount of basic data indicates that the 100-300 plots specified by the standard procedure[1] for constructing yield tables is entirely adequate. Suitable data for such an analysis have not been available before, but the methods used in the recently completed Douglas fir yield study have furnished the necessary basis.

The method used in collecting the data was the "tract" system, in which a number of nearly contiguous plots were taken in each stand sampled. These plots were numbered in sequence of measurement. In constructing the yield tables the averages of these groups of plots, the "tract averages," were handled as are single plots in the usual method of constructing such tables. The 179 tracts so obtained represented 1,298 individual plots, the number ranging from 1 to 22 per tract. The complete records make possible the following analysis, using total basal area for the various comparisons. For each "tract average" and plot an estimated basal area corresponding to its age and site index was read from the yield table. The percentage deviation from the estimated value was computed for each tract and plot. Average percentage and aggregate deviations from the yield table were then computed for various groups of data.

For the tracts the aggregate deviation was 0 per cent, and the average percentage deviation was 13.1 per cent. For all plots, treated separately, these values were —0.1 per cent and 14.1 per cent, respectively. Since the average deviation of individual values is always more than the average deviation of their group-average values, the average deviation of the tracts will be greater than that of the individual plots. The reduction in this value obtained by using tract averages is surprisingly small, amounting to only 1.0 per cent. The small difference in aggregate deviations is due to the different weights[2] of the two groups.

[1] Methods of Preparing Volume and Yield Tables. Committee Report. Journal Forestry XXIV, No. 6, Oct. 1926, p. 653-666. Item 42, p. 659.

[2] Each tract was given equal weight in computing the aggregate deviation of the tracts, and equal weight was also given to each plot in computing the aggregate deviation of the plots. Since the number of plots in each tract was not uniform the aggregate deviations so computed are not identical.

The plots were next grouped according to the sequence of measurement, the first plot measured in each tract being put into the first group, the second plot measured into the second group, etc. The average percentage and aggregate deviations of each group are shown in the figure.

The average percentage deviation is fairly constant for all groups, while the aggregate deviations rise to and above that of the tracts. The maximum aggregate deviation of groups of plots is +2.3 per cent. The deviations tend to increase because the first plots in stands of small area were taken near the borders, while those measured later were mostly in the central, better part of the stand, although some border plots are included in these groups. The plots measured last were also near the opposite borders, but their effect was obscured by the variation in number of plots per tract, which caused the last plot of one tract to be grouped with the middle plot of other tracts. This counteracted any tendency for the aggregate deviation to fall off in the later groups. To determine the deviations which would result from measuring only one plot in each tract, the middle plots (in sequence of measurement) were grouped together and deviations computed. This method of selecting the plots is the best available for determining which plot would have been taken in the field as the most representative one.

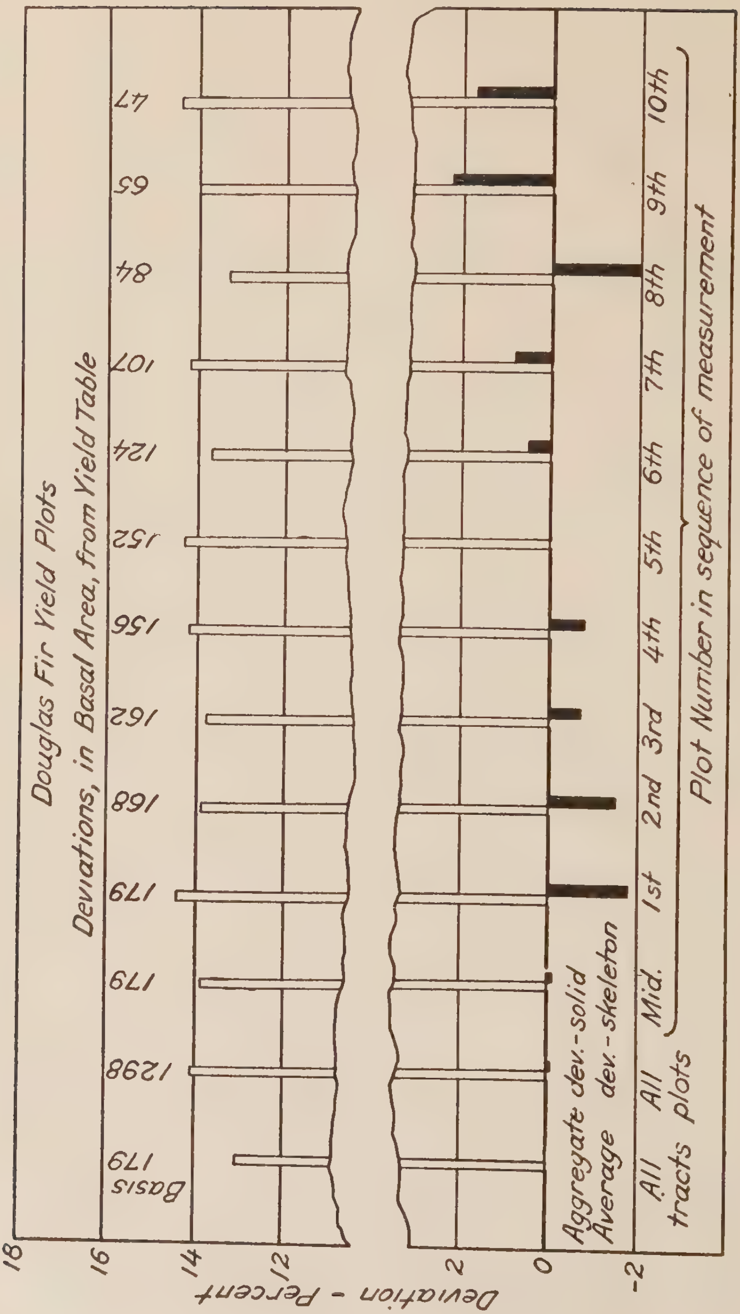
The aggregate deviation of this group was —1.1 per cent. The average percentage deviation of 13.9 per cent is almost the same as that for all plots, being only 0.2 per cent less.

The Douglas fir yield tables covered a range of ages and site quality equivalent to 135 ten-year age—ten-foot site index[3] classes.

A statistical analysis of this material, using its standard error and three times the standard deviation of its mean, indicates that a table covering this range and built upon the 1,298 plots, treated as individuals, would have been, on the whole, within ±1.5 per cent of the true mean, or table. The number of plots necessary for a given degree of accuracy

Accuracy of Table	Number of Plots Necessary	
	Total	Per 10-yr. age—10 ft. site index [3] class
+ 1%	2820	21
+ 2%	704	5
+ 3%	313	2
+ 5%	106	1

[3] This is figured on the more usual site classification age of 50 years, rather than on the number of classes based on the 100-year classification age used.


Douglas Fir Yield Plots
Deviations, in Basal Area, from Yield Table
Basis
179
1298
179
179
168
162
156
152
124
107
84
65
47
Aggregate dev.-solid
Average dev.-skeleton
All tracts
All plots
Mid.
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
Plot Number in sequence of measurement
18
16
14
12
2
0
-2
Deviation - Percent

is shown in the table below. A fairly normal distribution of plots is assumed, of course, in deriving and applying the values given.

The third column of this table shows the approximate number of plots per 10-year age—10-foot site index[3] class. These figures apply directly, of course, only to second growth Douglas fir. Judging by the average percentage deviation of total basal area of several other species, however, the above table should apply quite generally to many of our species which grow in pure, second growth stands. Mixed stands will probably require more plots for equal accuracy, but further work on other species will be necessary before the above table can be accepted for general application.

THE OBJECTIVES OF FOREST FIRE-WEATHER RESEARCH*

By H. T. Gisborne
Northern Rocky Mountain Forest Experiment Station

The purpose of our forest fire research is to provide the forest protective organization with complete and reliable information concerning the possibility of fires starting and their behavior, in the future. I would like to emphasize that word "future." Our searches of the records for the facts have to deal with conditions which have passed, post-mortem examinations, but the criterion of value of the results is the possibility of using the relations found so that future fire danger may be predicted more accurately. Unless our investigations show how the results may be used in this way, they have served merely to produce an alibi, a reason for censure, or a reason for commendation of the protective organization. No contribution has been made to the improvement of future protection unless each study shows what to look out for in the future, and how to recognize the danger before it occurs. Many students of the fire problem seem to have been content to establish explanations of what happened in the past. That is a means to an end, not an objective.

The first step in all well-founded forest fire research is the determination of what causes forest fires. The records for the National Forests and for state and private forest lands now cover a sufficient period of time so that reasonably accurate statements can be deduced showing the origin of the forest fire problem. In the northern Rocky Mountain region, for instance, the records for the National Forests show that during the ten years, 1916 to 1925 inclusive, just half the fires originated in lightning. The nearest rival is "campers and smokers" with only 13 per cent of the total number of fires chargeable against this source. Consequently the weather immediately assumes a position of paramount importance as a cause of fires in this region, regardless of its effect on behavior after starting. And the study of lightning as a source of fires becomes one of the fields of forest fire research, with the objective of predicting when and where fires will be started by lightning.

In the northern Rocky Mountain region the method of study has included the observation and recording of lightning storms by the fire lookouts stationed on the higher mountain tops. Although the reports have been summarized only for the past four summers, the results show

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several facts not fully appreciated and used in protection before this investigation was started. Most of these facts pertain to the probable occurrence of lightning storms in time and place, and to the characteristics of storms which indicate the degree of danger inherent in them. Such results should be of value in predicting future danger.

It was found, for instance, that if the lookouts would report to their rangers the first appearance of each lightning storm entering their districts, this warning usually would be five hours in advance of 46 per cent of the first fires caused by this storm. Such a warning, although short, is obviously better than none at all. The compilation also showed that in northern Idaho one storm out of two will start fires, whereas in eastern Montana only one storm out of ten starts them. In both regions the degree of danger inherent in a storm may be gauged roughly by the number of minutes rainfall ahead of and following the lightning, the greater danger being expected when there is less than 10 minutes of rain ahead of the lightning and less than 40 minutes following it. Similar warnings and criteria of danger also were obtained on other phases of the lightning problem. As the study is only four years old, it is altogether reasonable to expect that considerable information of additional value in predicting fire danger will be obtained in the course of time. One of the most promising possibilities is the 36 to 48-hour forecasting of lightning storms by the Weather Bureau which will be helped for the forest regions by the complete observation and recording of the storms in the present study. Heretofore the Weather Bureau has received only very fragmentary evidence of lightning storm occurrence in the forest regions as compared to the vicinities of cities at low elevations in generally non-forested areas. The fact is apparent already that the forested mountain areas experience two or three times more electrical storms than the low country where most of the regular Weather Bureau stations are situated.

The second phase of the fire-weather problem deals largely with the behavior of fires; the conditions permitting ignition, and the factors affecting the rate of spread. The application of this knowledge lies in methods of suppressing fires. In any work on this phase of the problem, it is helpful to keep clearly in mind that, except for lightning, none of the weather elements is a cause of forest fires. Hence any attempt to correlate number of fires with any particular weather element includes the variability of the causative agencies, and must account for that variability, or prove constancy, before anything more than accidental or sympathetic correlation can be shown. Rain, temperature, humidity, wind, and sunshine influence the starting of fires, and their number, only

as they affect the condition of the fuels. When the condition is favorable to ignition then the number of fires will depend entirely upon the presence and activity of the causative agencies. The logical sequence of information which we need for better forest protection includes: first, the presence and activity of those agencies which start fires; second, what conditions of the fuels permit ignition by these agencies; and third, how does each of the weather elements influence the condition of each of the fuels?

For the northern Rocky Mountain region we know rather accurately the time, place and activity of the most important causative agencies. We know that none of these agencies is effective in the duff when the moisture content of the top layer of that fuel is over 25 per cent. When the moisture content is between 18 and 25 per cent we must watch for duff ignition by lightning and by broadcast slash fires. At 13 to 18 per cent duff moisture we must watch for ignition by lightning, broadcast fires, slash piles, and camp fires. If the moisture content drops below 13 per cent, but stays above 10 per cent, blazing embers and matches must be guarded against. At 7 to 10 per cent smokers' butts may become dangerous. And below 7 per cent all agencies are generally effective. The same line of research must now be applied to other fuels, especially small and large wood in both sound and decayed conditions.

To use this information for predicting future fire danger we must know how each of the atmospheric elements affect the moisture content and ignibility of each of the fuels. Research has already contributed considerable information on this phase of the problem, concerning the effects of rain, temperature, humidity, wind, sunshine, etc., including combinations such as evaporation. At present this is the phase which seems to be receiving an unwarranted share of our effort. More research is greatly needed concerning the different kinds of fuels, and their characteristics, including size, total volume, ratio between surface area and total volume, arrangement, state of decay, chemical composition, etc. This phase of the problem is almost untouched as yet. For instance, who knows the amount of heat required for the ignition of tree moss, twigs, slash, duff, snags, etc.? Who knows the amount of heat liberated by the combustion of equal volumes of each of these materials? Who knows what size and shape of material is most dangerous? Who knows the moisture content at which a rotten log can be ignited by a spark, and the moisture content above which the same spark will not be dangerous? Since rain, temperature, humidity, and sun-

shine affect fire behavior mainly as they affect fuel moistures, it is very probable that we must answer these questions before we can tell dependably how the atmospheric factors affect the ignition of the fuels and the behavior of forest fires.

If the object of this research work is better future protection, the application of this knowledge must carry on to cover the tactics of fire suppression. Many of the trenches dug around fires this last summer were of just about the same width and made by the same method as were those constructed to suppress the fires of 1910 and 1915. Pumps and plows were more in evidence, but the majority of the suppression was by handmade trenches, all too frequently of a constant width regardless of the character and volume of the fuels being burned. Personal opinion was the principal factor determining the use of backfiring. Our service of supply has been developed wonderfully during the past 10 or 15 years, but the improvement of action in the front line trenches has not kept pace. Are there not certain fundamental conditions which should indicate the superiority of one method of fire suppression as compared to another? Is it not probable that these conditions vary according to timber type, topography, weather, etc., and that they should be studied and worked out separately for each region? Here we have another field almost untouched as yet by research; a field in which action is becoming more and more settled to rule-of-thumb procedures which frequently fail to consider all of the important factors involved. This field of research is of minor importance, perhaps, compared to the acquisition of knowledge on which the tactics of suppression must be based. It deserves mention, however, in any attempt to outline the various phases of fire-weather research.

At the Northern Rocky Mountain Forest Experiment Station we are investigating all of these problems. We appear to be making progress in solving some of them. We can measure duff and slash moisture content instantly and as often as desired. We know the relation between duff moisture and duff inflammability accurately enough to distinguish six degrees of duff inflammability. We do not yet know the relation between wood moisture content and wood inflammability. We know fairly accurately the duff moisture content to be expected according to rain, temperature, relative humidity, and the evaporation rate, hence we can interpret weather forecasts into terms of duff moisture and duff inflammability. As yet we cannot interpret weather forecasts into terms of either wood moisture or wood inflammability.

When we know all these relationships, however, the information

will be of no practical value until it can be translated into terms of the future. Measurements of fuel moisture contents and observations of the behavior of going fires will tell the degree of present danger: to improve protection we must know what the danger is going to be. The connecting link, largely missing as yet, is accurate and detailed weather forecasts. Here we encounter the most important single phase of our problem. What does it avail us to know to a nicety the relation between relative humidity and fire behavior if we cannot predict relative humidity? How are we going to use the complete knowledge previously outlined of the relationship between each atmospheric factor and each forest fire fuel if we cannot forecast the atmospheric factors? We are engaged in research work with the objective of better forest protection. The crying need of better protection is an accurate statement each day of the degree of fire danger to be expected the next day and the day after that. We can take accurate weather forecasts and guess at the results in terms of fire danger with very fair chances of success. We can take perfect knowledge of the effects of the atmospheric factors on fuel moisture contents and use them for nothing but alibis unless we have dependable weather forecasts.

Although weather forecasting is the field of meteorologists, the assistance of foresters is needed to obtain the desired results. The U. S. Weather Bureau already has entered this field with all the force permitted by its finances, but they cannot predict for a region from which they obtain only scattered measurements. Here the foresters must enter by obtaining accurate and systematic records for study by the meteorologists. It is a humdrum job requiring the services of many men, but it must be done if we want accurate weather forecasts. Very few investigators are engaged in studying weather forecasting for the forested areas, whereas many meteorologists as well as foresters are studying the relation between the atmospheric elements and fire behavior. I contend that our present efforts are unbalanced, and that in the near future we are apt to find ourselves in the position of the starving and toothless man who was presented with the juicy steak. The prospects of accurate information concerning the weather elements and fire behavior appear to be good—the juicy steak is in sight—but we will surely starve (or burn) looking at it unless we help the meteorologists to provide us with a good set of teeth in the form of weather forecasts. As the manufacture of the teeth may take considerable time we had better recognize the key position of this phase of the problem and get at the job with all our resources.

WEATHER AND FOREST FIRES*

By C. S. Chapman,
Weyerhaeuser Timber Company

It has long been known to foresters, and those engaged in forest fire prevention and suppression, that behavior of forest fires depends principally upon weather conditions. That fires spread more rapidly after periods of drought and when fanned by high winds and that lightning storms cause fires is fairly obvious. But, until comparatively recent times, it was not so apparent why fires would burn fiercely one day and the following one, with equal wind velocity from a different direction, die down and become comparatively easy to control. Nor was it so well understood why lightning storms with moderate precipitation, over a given area, might cause few fires, slow to spread, and easy to control, while again, with equal precipitation, another series of storms would cause numerous fires which burned with great intensity.

The obvious relationship between weather and fire hazard caused to be started, early in 1916, a movement to secure advance information, from the U. S. Weather Bureau, of occurrence of periods of fire weather. These forecasts were initiated by Mr. Edward A. Beals, at the time District Forecaster at Portland, Oregon. Early forecasts were confined largely to warnings of lightning storms and high winds, particularly the much dreaded easterly ones which early gained evil repute among fire protection agencies.

The desire to perpetuate our timber resources had by this time progressed to a point where it was considered necessary to protect not only virgin timber but, as well, areas where reproduction had started or would start in the absence of repeated burning. There very naturally soon followed a period of intensive investigation of causes for the variation in the fire hazard. These investigations were carried on independently by members of the Forest Service, state and private protection agencies. Nearly all of the investigators arrived at practically the same conclusion. While the terminology of the findings has differed somewhat, due to the differing climatic conditions and forest types dealt with in different areas, consensus of opinion is that, other conditions being equal, the degree of forest fire hazard varies inversely with the amount of available water vapor present in the atmosphere. While some au-

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thorities use as an index of hazard absolute humidity, as indicated by the vapor pressure or the temperature of the dew point, and having to consider current temperature with relation to both; the majority incline to the belief that relative humidity, or percentage of saturation of the atmosphere, is a simple and readily comprehended index. Further studies, over large areas and under differing forest conditions, serve to strengthen this belief.

Having isolated and identified the fire hazard "germ," it followed logically that there should be demand for a greater degree of localization of the fire-weather forecasts of the Weather Bureau. There being no specific funds available to the Weather Bureau for this purpose, it was impossible for the Bureau to assign special personnel to an intensive study of fire-weather. But, under the direction of Mr. Beals, then at San Francisco, all available time was given to fire-weather studies and some extension of forecasts, with regard to local changes in humidity, resulted. This situation continued for several years, and, during this time, protection agencies urgently requested the establishment of a "Fire-Weather Warning Service," which the Weather Bureau, due to lack of funds, was unable to furnish in a desirable manner.

The spring of 1924, however, the general desires and requests for Weather Bureau cooperation were crystallized through a specific offer that, if the Weather Bureau would assign special personnel to a study of the fire-weather situation in Washington and Oregon, the various protection agencies of these states would defray necessary expenses incident thereto. This offer contemplated field expenses of the assigned personnel as well as necessary instrumental equipment. It also embraced furnishing of observers to carry on the field work throughout the fire season. With a desire to be of greatest possible service, this offer was accepted by the Weather Bureau, and, in July, 1924, two meteorologists were assigned to the work, one with headquarters at Seattle and one stationed at Portland. Statewide surveys of humidity and temperature in forested areas were at once initiated, and, by the end of the season, a fairly comprehensive reporting organization had been perfected. Credit for this rapid progress is jointly due to the Weather Bureau representatives and the protection agencies; the former for their expert knowledge and industry and the latter through furnishing necessary instruments, observers and funds. Additional material for the survey was furnished through the climatological service of the Weather Bureau, reporting temperature, precipitation and evaporation data for the two states.

Dissemination of fire-weather forecasts for the two above mentioned states was transferred from San Francisco to the Bureau headquarters at Seattle and Portland, and their adaptation to local conditions was attempted, with a marked degree of success.

Fire-weather service continued until the summer of 1926 under the above conditions, i. e.: with Weather Bureau personnel available for the work during the summer months only, devoting their time in winter and early spring to other projects and dependent on the cooperating organizations for financial support. In the spring of this latter year, through efforts of the Western Forestry and Conservation Association, funds were appropriated by Congress for establishment by the Weather Bureau of a Fire-Weather Warning Service. There then followed the establishment of seven districts—No. 1, California; No. 2, Oregon; No. 3, Washington; No. 4, Montana and Northern Idaho; No. 5, Southern Idaho; No. 6, Minnesota and the Northern Peninsula of Michigan; No. 7, Adirondacks and New England (except Connecticut). Provision was made in the appropriation act for full-time service of meteorologists, distribution of the forecasts by wire and receipt of special messages from the field, a certain portion of necessary travel expense, and the purchase of instrumental equipment. Fire Warning Service has thus been given official recognition as one of the special activities of the Weather Bureau; and, with reasonable certainty of permanence through a continuance of adequate Congressional appropriations. With the accumulation, over a period of years, of pertinent data, the gradual enlargement of the physical scope of the surveys already commenced, and the opportunity, now given for the first time, for intensive study of data all ready and to be collected, there should be marked improvement in the quality of the forecasts as to accuracy, timeliness, localization and scope.

Much has been done, by both foresters and meteorologists, along the lines of investigation of fire weather, its causes and effects. But there is pressing need for further research, utilizing not only the intensive seasonal data now being collected but also available past records, both concerning fires and weather, with a view to confirming or disproving theories now accepted and to the discovery of hitherto unknown factors and relationships.

While acute fire weather is, fortunately, generally somewhat local and of but short duration, the seasonal fire hazard over large areas is influenced by practically every variation in each element of the weather for each day of the year. This broad generalization, like all of its kind,

is subject to exceptions. Normally, the fire hazard varies with the seasons, being least during those of greatest precipitation or succulence of vegetable tissue and greatest during the months of least rainfall, high temperatures and desiccation of fire material. In some localities, these periods—precipitation and succulence—coincide, in others they do not. Periods of acute fire hazard are marked by subnormal humidity and generally by winds of more than average velocity. While periods of extremely low humidity, accompanied by desiccating winds of high velocity, may and have caused acute fire hazard with vast resultant damage during an otherwise favorable season (notably the Yacolt Fire in Southwestern Washington in September, 1902 which covered over 50,000 acres and happened at the end of a summer marked by an excess of precipitation in the area affected), in general, the percentage of relative humidity, necessary to cause an increase in the seasonal fire hazard, varies according to the condition of the fire material which, in turn, varies with the general character of the season.

As an example, the fire season of 1926 in the state of Washington may be taken. This season was marked by an unusually large number of troublesome fires, large areas burned over and the greatest expenditures for fire prevention and suppression in the history of organized protection. This situation was true both east of the Cascades, where losses were heaviest, and in the Douglas fir belt. In the Coast region, however, there did not occur, during the period when fires were troublesome, a single period of really acute "fire weather." There was an absence of high east winds with extremely low humidity. The real weather history of this season must begin with the winter of 1925-26, which was marked by generally subnormal precipitation throughout the state and less than the average snow-cover in the mountains. Abnormally high temperatures in February, March and April caused a rapid melting of the snow blanket, with rapid runoff and a serious depletion of the store of subsurface moisture that should have been available during the summer. There was also a pre-seasonal development of fern, weeds, brush and tree foliage. Continued high, though not extreme, temperatures during the spring and summer hastened the loss of succulence and seasonal high inflammability of fire material. Thus the stage was set for an abnormal season. Conditions existed in early July which normally are not to be expected until middle August or September. Occasional periods of low humidity were experienced in March, April and May, but general conditions were still such that but little damage resulted. Late June, July and the first half of August witnessed a suc-

cession of periods of rather low humidity interspersed with other periods somewhat higher but generally below normal for the season. No effective precipitation occurred from late June to the middle of August. The reaction of the forest material to changes in the relative humidity seemed greater than would be expected during a season of normal precipitation. Lack of subsurface water made for slower recovery by vegetation of moisture lost through transpiration during the periods of low humidity. The result was increased inflammability. During July and August, fires became active when the relative humidity reached 40 per cent, whereas 35 per cent was the normally accepted danger point of previous seasons. Fires were readily started, at all times and difficult to control, and this condition continued until August when copious rainfall relieved the situation.

East of the Cascades, a region of normally lower humidity, with the danger point at 25 rather than 35 per cent, abnormal seasonal conditions were accentuated. Early in July, a series of lightning storms caused many fires in Northeast Washington, Northern Idaho, Western Montana and Southeastern British Columbia. Due to abnormal conditions, these lightning fires spread much more rapidly than is usually the case. Many of them continued until the August rains, and losses of timber and watershed cover were severe.

In both eastern and western sections, fire hazard during the period of greatest damage was great from seasonal rather than from periodic causes. There was bad fire weather for a long period, but, fortunately, no such acute period as that which caused the Yacolt fire. Had such a situation developed, it is beyond human imagination to predict what might have been the result.

Generally then, the weather affects the fire hazard; first—by its seasonal effect on the normal course of development of fire material, which effects are patent to all concerned and need not be the subject of forecasts; secondly—by occasional and sporadic, more or less acute, departures from the seasonal forms of humidity, wind direction and velocity, causing acute inflammability of fire material; and third—through the occurrence of lightning storms, which are responsible for a high percentage of our forest fires. The last two phases are those, the forecasting of which enables fire prevention and suppression agencies to take added precautions.

To be of value, such forecasts must be accurate and highly localized. They are becoming so to a greater degree as each season brings new data and new phases of the problem. Use of forecasts is also be-

coming general. The issuance of permits for burning in towns, in the country and in slash disposal is more and more based on weather forecasts. Fire wardens and rangers arrange their regular and reserve forces to meet changes in fire hazard; loggers change their hours of work or suspend operations when unfavorable weather is forecast; while those in charge of suppression of major fires are given daily advices as to weather conditions 24 hours in advance, so that they may intelligently plan their line of attack. The theory that weather controls the fire hazard has been very generally sold to those engaged in protection of our Pacific Coast forests.

FIRE-WEATHER FORECASTS NEEDED BY FIRE CONTROL EXECUTIVES*

By Roy Headley
Chief, Branch of Operation, U. S. Forest Service

It is needless for me to present to this audience any discussion of the intimate relation between weather and forest fires. I shall confine myself to a brief treatment of the problem of fire weather from the standpoint of the executive who must so adapt his management of fire control forces that losses will be kept at an acceptable minimum, regardless of fluctuations of weather and other factors of fire danger.

We are all aware of the fact that the fire control executive is interested first of all in extremes of fire weather. He has fairly well mastered the job of fire control when weather conditions are normal but he has not yet found out how to deal adequately with fires when unfavorable weather factors are extreme either for a season or a few days during a season. A measure of the importance of extreme fire danger may be had in the fact that on the National Forests half the losses in area during the nineteen years 1908 to 1926, inclusive, occurred during the three extreme years 1910, 1917, and 1919. Weather was the chief factor which made those three years so disastrous.

In most National Forest regions bunching of lightning fires is the climatic effect most dreaded. We had our first serious experience with bunching of lightning fires in 1917 when over a hundred fires were set on one National Forest by one storm. In subsequent years bunching of lightning fires has tended to grow more pronounced until in 1926 we had 153 recorded fires from one storm on the Kaniksu National Forest of less than three-quarters of a million acres. We would like to believe that a favorable swing of the weather cycle is due and that in future we will not have to contend with so many fires at one time. We have no basis in fire or weather history for such a hope, however, and we have as much reason for expecting that such bunching of fires will grow worse as that it will grow better.

When such extreme concentration of lightning fires occurs, the best we have been able to develop so far in the way of organized fire control simply breaks down or rather proves quite unequal to the demands of such a situation. Foresters grow heartsick and the business of timber production in such regions is challenged when we sustain

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such losses as occurred on the Kaniksu during the past season. It would be practicable to provide enough men, equipment, and improvements on one or on a few National Forests so that such bunching of lightning fires as we have experienced up to this time would not result in serious losses but that is not the problem we are facing. Judging from past experience extreme bunching of such fires may occur on one or more of thirty-five or forty National Forests averaging more than a million acres each. The trouble may be confined to a single forest or may strike a dozen or possibly all of them at one time. There is no way of knowing where these dry electrical cloudbursts will occur next. To provide sufficient man power and equipment on all the forests which are subject to this particular danger has not been practicable so far. We, of course, have definite programs for coping with this danger on all these forests but these plans remain in the class of things which we expect to do rather than in the group of things actually accomplished. In the meantime, while we are strengthening our fire control resources we have urgent need of all the aid the fire weather experts can give us by forecasting extreme electrical storms in order that all possible adjustments of personnel, equipment, etc., may be made to meet the demands of particular situations.

Regional predictions of thunder storms are seldom of much value because, for example, in our northern district (North Idaho and Montana) the records show that such storms occur somewhere in the district on from 85 to 95 of the 122 days intervening between June 1 and September 30. Reliable localized predictions of thunder storms would be much more useful. However it should be noted that we have facilities for detecting the approach of local electrical storms which we will undoubtedly learn to use more effectively. The approach of such storms is usually apparent to the lookout man for from one to several hours before fires are started in the area for which they are responsible. This interval of time is sufficient to give the order "make ready" to guards, rangers, trail crews and cooperators already in or near the woods and much can be done by them to facilitate speedy action when fires are later discovered and reported by the lookout.

Neither regional nor localized predictions of thunder storms has a value to the fire control executive that begins to compare with the value which reliable predictions of extreme electrical discharges would have for him. Whether it is possible for meteorology to distinguish between those conditions which produce ordinary electrical discharges and those which produce extreme discharges I do not know but I have

confidence that time and persistent investigation will make such distinctions possible.

Another phase of fire weather which worries the fire control executive has to do with the growth of fire danger in the spring. After the fire season is started ordinary fluctuations of fire weather are of little concern to the executive. He is organized and equipped for all the usual degrees of fire danger and little change in management of his forces is called for by fluctuations from favorable to fairly critical weather. In the spring the problem is entirely different. In an occasional spring serious fire danger arrives weeks or even months earlier than the normal or average date. Sometimes occurrence and dangerous rates of spread of fires begins with a bang instead of gradually becoming worse as the season advances. Normally, in the spring, a rain is followed by days or weeks of drying weather, falling humidity and rising temperature. Then comes another rain and the cycle begins over again. But will the days or weeks of dry weather and falling humidity be closed by a rain, or by a dry electrical storm and a wind? The executive never knows but he has to make vital decisions from day to day with little to guide him except his guess as to which way the weather is going to swing.

The force of fire guards is not needed at their stations until real fire danger arrives. So long as normal spring rains occur with reasonable frequency and no serious lightning fires are started these guards are needed on trail and telephone work and on many other badly needed jobs. But at infrequent intervals some of our worst electrical storms occur before the average date on which the period of serious fire danger begins. Also exceptionally low humidity and drying winds of high velocity may suddenly appear instead of the rain that should follow a period of clear days. These unexpected things may find the executive with his forces not placed for fire work, telephone maintenance not completed and generally unprepared. Yet he can hardly plan to manage *every* year for the worst and earliest opening of the fire season that may happen. He does the best he can. He guesses and gambles. He needs expert weather advice to guide his judgment of each particular situation. Short time predictions give him little help in the spring and forecasts of fire weather ahead are not what he needs. He wants to know what to expect a week or more ahead and particularly he wants to know the *degree* of danger which will result from all the factors. He needs a reliable index which will integrate all the factors which influence the gradual change of fire danger from the stage of safety up to the normal or extreme level.

Wind and humidity affect fire danger in numerous ways. Better forecasts of both would make for more intelligent handling of fire control in many ways. Changes in humidity are particularly important on the West coast in Oregon and Washington and in the Atlantic States. If by study of radio static or in any other way, meteorologists learn how to predict significant changes in humidity a day or more ahead both fire prevention and fire suppression will greatly benefit.

Predictions of critical weather if reliable may serve the fire control executive by suggesting to him that rangers and some other officers should be held on the telephone line for a time instead of going about their regular duties. Such predictions may be used as the basis of special warnings to recreationists and forest users given over the radio, over the telephone or by personal contact. Areas may be closed to use because of such forecasts and the danger of man-caused fires averted. Considerable use is already made of fire weather warnings in control of slash burning operations and such uses will be extended steadily. All of these are important but the thing most desired at this time is reliable forecasts of extremes of fire weather and the rate of increase of fire danger in the spring.

WEATHER AND FIRES FROM THE STANDPOINT OF THE METEOROLOGISTS*

By Meredith Frederic Burrill
Lehigh University

From the standpoint of the man in the street, the value of fire weather work lies in the better protection of our forest resources. From the standpoint of the producers of forest products the value lies in the reduction of loss of raw materials.

The function of fire weather work is briefly this: To determine the ways in which forest fire can be most effectively combated and most nearly prevented, that the forest resources, the raw materials, may be best preserved.

Successful fire weather work requires the active cooperation of foresters, meteorologists and those interested in the utilization of our forest resources. When the foresters have determined by observation and experiment the conditions most conducive to the start and spread of fire, the meteorologist can determine the sequency of events which leads to the development of the dangerous conditions and forecast their occurrence. The companies must cooperate with forester, meteorologist and with fellow companies to put into practice the remedial measures which may be found necessary. I emphasize the fellow companies because the most painstaking precautions of a conscientious logger may be set at naught by fire spreading from the properties of a less careful neighbor.

Thus some interests, while recognizing the importance of the work, are unwilling to institute the reforms whose benefits may be lost through the negligence of a neighbor. With all those concerned cooperating freely it should be possible to materially reduce the needlessly great fire loss.

The Weather Bureau and the Forestry Department are at present cooperating to maintain fire weather investigation in New England. The Forestry Department pays for the time spent in the forest by the investigator, Mr. Crombie, and the Weather Bureau remunerates him for the time not actually spent in the forest. An outlay by the producers for meteorological instruments, or for meteorological information, or the loss of revenue consequent upon a cessation of operations for a few days, would be more than repaid by the prevention of loss from one small fire.

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THE FUNCTION OF THE METEOROLOGIST

The function of the meteorologist in fire weather work is (1st) to help the forester to determine the factors which bring about hazardous conditions, and to ascertain the sequence of these factors, and (2nd) to forecast the occurrence of the hazardous conditions upon the basis of the predetermined controlling atmospheric conditions, with the aid of Government weather maps and the Weather Bureau forecast.

Forester and meteorologist must cooperate to determine the nature and cause of fire hazards, to bring to the solution of the problem the training and equipment of both professions. The inflammability of the fuel is of course the governing factor in the start of fire and one of the most important factors in its spread. The foresters have shown that when the duff, the layer of leaves, needles, and raw humus on the forest floor, contains water to the extent of 25 per cent or more of its dry weight no ordinary brand such as cigarette stub or pipe heel will start a fire, for the heat from the brand will be exhausted before the moisture content is lowered to the inflammability point. As the moisture content decreases the ease of inflammability increases until at seven per cent saturation any of the ordinary brands will ignite the fuel with which it comes in contact.

THE SEQUENCE OF EVENTS LEADING TO DUFF INFLAMMABILITY

The degree of inflammability depends on the moisture content, temperature, and size of the fuel as well as the ease with which it will dry when heat is applied. In the last analysis it all comes back to the question of the inflammability point as determined by the moisture content. As soon as the water content is sufficiently low the fuel will ignite. Size, temperature, and ease with which the fuel will dry on the application of heat, are thus effective in determining the amount of heat necessary to drive off the excess of water above the inflammability point. The extreme hygroscopicity of the duff and small wood fuel leads us to expect that the absolute and relative humidity of the atmosphere may play an important part in determining the rate of reduction of the moisture content of these fuels. Studies carried on by the Northeastern Forest Experiment Station indicate that a tenth of an inch of rain suffices to keep the moisture content of the duff above 25 per cent for a period of three to four days, and that the danger-free period is longer when the humidity is high than when it is low.

Investigation has shown that relative humidity, through its control of duff moisture content is, in some localities at least, an excellent index

to fire hazard. May I cite here the results of a study of the relationship between relative humidity and fire incidence, made by Miss Dorothy V. Noble. This is but one illustrative study of many such which I shall not take the time to mention.

This study shows very clearly the varying degree of hazard coincident with low humidity, and the consequent difficulty in establishing a definite "dangerous" humidity without considering the season.

The fire data were furnished by the Lake States Forest Experiment Station and pertain to Fire District Number Two of the State of Minnesota, about 4,500 square miles of conifer and mixed hardwoods forest. The humidity data were supplied by the Minneapolis Weather Bureau Station from the noon readings.

"Low incidence during the month of April as compared with May was interpreted to indicate the beneficial effect of the snow cover which usually persists through April, but is absent in the succeeding month. The fires occurring in April have apparently little direct relation to the relative humidity. While the general trend is much the same in May the incidence of fires is higher. The correlation between the low relative humidity and the number of fires is too greatly accentuated by the occurrence of five fires on May 26, 1923, with a relative humidity of 20 per cent—the only time during the four years that the relative humidity fell that low during May.

"In the comparison of the May and June graphs, May again shows a predominantly greater incidence, which is this time presumably accounted for by the lack of heavy foliage during that month as compared with the protective, full foliage of June. Of the spring months, then May is the period of greatest fire danger. With a humidity between 21-50 per cent, the average hazard is approximately one fire for every two days, with a rapid increase below 20 per cent, while in April the probability is only one fire every five days in the same percentage range and in June less than two fire days out of five.

"The July curve indicates a marked progression of increasing fire hazard with decreasing relative humidity with an average of one fire every four days of relative humidity below 50 per cent. The August curve has the same trend, but with a much higher incidence of nearly one fire each day of relative humidity below 50 per cent. There is a notably regular progression below 40 per cent for the three months, the number of fires doubling from June to July and again from July to August.

"With the coming of autumn and the period of greatest fire hazard the relationship is markedly strengthened. The general increase

of fires with decreasing relative humidity indicated so clearly from month to month during the summer, is most marked in the September curve and is only less slightly pronounced in the October one. While August has scarcely one fire for each day falling below 50 per cent, September's average rises to a frequency of 2-1/3 per day. The average again drops to a probability of little more than one a day for October. The greater number of September fires may be due to the accumulation of a new dry covering from the defoliation of the trees and to the decreasing rainfall, both conditions especially favoring inflammability. In October the first of the winter snowfall begins and is probably a factor in curtailing the hazard, especially in the latter half of the month.

"Omitting the influence of other possible factors there is a notable tendency for forest fires to increase in number with a decrease in the relative humidity. The relationship is most marked in the late spring and early fall. In both of these seasons the danger is most excessive with relative humidity below 30 per cent though the danger may be considered imminent with any condition below 50 per cent. Above that value the fire hazard decreases about in proportion to the increase in relative humidity."

FORECASTS OF SPECIAL ATMOSPHERIC CONDITIONS

Since relative humidity is unquestionably a factor in fire incidence and probably in most cases the prime factor, it has seemed advisable to devise some means of forecasting it. To that end the writer devoted a portion of a year of graduate work. Several methods of forecasting resulted, of which I need mention only those easiest to apply. The most successful method is as follows: Two factors which when combined give a figure of relative humidity, namely the temperature of the dew point and the temperature of the air, were both forecast in the morning for the dangerous period, two to three o'clock in the afternoon. The two forecasts were then combined to give a figure of relative humidity. The success of this system is largely due to the fact that variations of the temperature from the normal curve for the particular wind direction and degree of cloudiness were usually accompanied by similar variations in the dew point curve, leaving the relative humidity figure unchanged.

The following results were obtained in trial forecasts made by this method at Worcester, Mass., on thirty-seven consecutive mornings in October and November, 1925. On eighteen occasions the forecast erred by five per cent or less, on twenty-two occasions the error was ten per cent or less, and on only five days was the error more than seventeen per cent.

By simply determining the average diurnal change of dew point and air temperature for each wind direction and for clear, partly cloudy and cloudy days in a given region, fairly accurate forecasts can be made even by non-experts from local observations. Fortunately, the forecasts are most accurate in time of relative hazard.

Two other methods of indicating the probable trend of relative humidity are sufficiently reliable to be of use.

Trend curves indicate with fair consistency the variation of the minimum humidity from that of the previous day. When the morning humidity is higher than on the day before the afternoon humidity will also be higher. The relationship held true in the instances observed sixty times out of sixty-two.

Another method of indicating the probable humidity is somewhat more definite. A study of the morning humidity values lined up against the corresponding afternoon humidity values in order of increasing magnitude reveals the fact that, at least during the months of May and June, 1925, at Northfield, Vermont, a morning humidity of 71 per cent or less foretold an afternoon humidity of 50 per cent or less in June and 40 per cent or less in May, except on days when there was a high wind from the south or southwest and the sky covered (.7) with stratus clouds. On the other hand, every morning humidity of 72 per cent or more was followed by an afternoon humidity of 50 per cent or more excepting four days when there was a light wind from a northerly direction and the sky was .3 or less covered with cirro-stratus clouds. Thus the morning humidity, plus a knowledge of the factors which will divert the regular course, may be converted into definite terms of fire hazard or safety.

Mr. Crombie, investigating the situation in New England, has indicated the desirability of a forecasting table for local conditions to supplement the regional forecast. It seems that some method such as those above referred to may be devised to meet this need.

The depression of the wet bulb may show a better correlation with fire incidence than does relative humidity, since it expresses more directly the rate of evaporation.

THE APPLICATION OF FORECASTS

The value of forecasts of fire hazard is wholly dependent upon the measure in which they can be applied. One of the ways in which the forecasts can be put into immediate practical use is in limiting permits to burn slash or grass. From the indication of the trend of humidity during the day, burning permits may be more surely re-

stricted to safe days. It may prove advisable to issue no burning permits before noon, in order that the person issuing the permit may have an opportunity to receive the forecast for the day. It may also be expedient to require each person receiving a permit to burn, to leave with the issuing officer a telephone address at which he can be reached at any time while the burning is in progress.

On Cape Cod most of the fires are due to sparks from locomotives. In this case it may be wise to send a hand car patrol a half hour or more behind all trains on days when the fire hazard is excessive.

Loggers may suspend operations and call the men out of the woods in periods of unusual danger, and may forbid smoking except on days of absolute safety. Portable sawmills may be required to suspend operations for limited periods, since they endanger not only their own logs and sawed lumber but also the properties adjoining.

RECOMMENDATIONS

In conclusion I wish to recommend; that further studies be made to determine the influence of meteorological elements separately and collectively upon the incidence and spread of fires; that to aid in such studies, more detailed data be collected, particularly of the approximate rate of spread of each fire on each day and in various periods of the day, dates when fires supposedly under control have gotten out of hand, and dates when fires were extinguished or brought under control; that all watchmen be equipped with psychrometers and instructed in their use, in order that information may be had on the variability of conditions within a large region; and that an organization be developed for the reception of reports from these observers and for the dissemination of forecasts.

WEATHER AND FIRE RESEARCH*

A REVIEW AND FORECAST

By S. B. Show
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In discussing weather and forest fires there is perhaps some justification for departing from the conventional procedure of reporting new discoveries and in attempting instead a critical look back at what has been accomplished and a look ahead at what remains to be done. The progress of the past half decade or so has been notable. Hoffman, Osborne and others have shown the importance of relative humidity of the air as a major control of the occurrence and spread of fires. In practically all the forest regions of the western United States the theorem that low humidity means fire danger is now generally accepted, and protection organizations, federal, state and private utilize information on humidity to a greater or lesser degree.

Even before this critical relationship was generally recognized, the U. S. Weather Bureau had begun its fire-weather warning service. As more exact studies on weather and fire have been prosecuted, and as the facilities of the Bureau improved, this service has been extended and strengthened and today is a genuine factor in fire control, particularly in the West. Short period predictions on a regional basis have become the general standard.

Once humidity was determined to be a control of first importance, foresters began attempts to forecast it directly, basing predictions on current readings of humidity alone. Some success was attained but it soon became evident that predictions for a particular locality were exceedingly uncertain, and that the major changes in weather, of which humidity changes were but a phase, could be foretold best by the Weather Bureau.

Fortunately, the idea that relative humidity was the sum total of weather influence on fire was not allowed to go unchallenged. Rate of evaporation was urged as a better measure of fire hazard, inasmuch as it took cognizance of temperature and wind, important elements with humidity in fire control. Here, too, it was found that as a basis for prediction, evaporation rate was no stronger than humidity.

A step of very great importance was taken in experiments begun by Gisborne in Idaho some years ago. These, for the first time, recog-

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nized that fire hazard was controlled directly by the moisture content of fuels and that fluctuations in humidity, temperature, wind and precipitation were important as they affected fuel moisture. The progress in this direction has been rapid, particularly in the development of instruments for measuring moisture of fuels in place, and in interpreting regional forecasts in terms of fuel moisture and hence of fire hazard. One clear result has been that a combination of weather factors rather than a single one is what must be watched. This has been found notably true in California where, as elsewhere, wind velocity is of at least coordinate weight with atmospheric humidity.

After the preliminary work was out of the way, it soon became evident that the wide variety of fuels in the western forests reacted at varying speeds to weather changes. In many old burns, with fireweed and fern as cover, the fuel reflected atmospheric changes with little delay. On the contrary, in dense virgin forest, the dense and compact litter and old logs showed a very decided lag.

Recent work has greatly increased our knowledge of the behavior of the principal fuels but a vast deal remains to be done.

As a general summary, it may be said that we have fairly blocked out the short term prediction problem and have furnished a fairly definite basis for regional predictions of changes in fire danger. The recent trend has been toward better coordination of the efforts of foresters and forecasters, particularly, in the direction of localizing forecasts. As this desirable trend develops, we should anticipate that the forecasting function should settle more and more where it belongs—in the Weather Bureau.

A further advance in the field has been in the study of lightning storms. This has taken the direction of analyzing the types of weather which result in the storms. This phase of the project has gone far enough so that the prediction of lightning storms by the Weather Bureau has begun. When it is recalled that in the heavy fire districts of the West, lightning fires occurring in large numbers are the most common cause of breakdowns in the protection, the importance of prediction, even for a short period, is evident.

Much study is being given to the characteristics of the storms—their paths, amount and duration of rain, whether it precedes or follows the lightning and similar data which will add greatly to our ability to organize for peak loads of lightning fires.

So much for the work of the past. A look ahead at the probable trend of weather and fire investigations may be of some value.

It is, I suppose, a common source of sorrow to research men and forecasters that information and predictions are not more generally and skillfully used by the men and agencies who are doing the actual control work. Let us recognize that some lag in the application of research results is inevitable and that a lot of failures to utilize available predictions are due to the inertia or skepticism of the men who handle the fire control work. But it would be a mistake to assume from this that either the research basis of fact, or the predictions are entirely satisfactory.

For one thing, neither the data nor the predictions have so far been generally related to the actual behavior of fires. As an example, most timber fires start as surface fires. They may and often do spread rapidly but without any essential change in their nature. For such fires, men skilled in fire control will build up a certain kind of organization, will adopt certain methods of attack and will, if it is necessary to look ahead to a several days' campaign, start strings of reinforcements. Now to the man in charge of a large fire, it is, of course, important to know that the fire hazard will increase. But at a certain point in the increase, the fire suddenly ceases to be a surface fire and becomes a crown fire. At once, different methods of attack become necessary, a different scale of organization, often a radical change in strategy on the entire fire. In other words, one very definite direction in which future research should go is to give specific knowledge of the conditions leading to crown fires. This study should seek to state, first, the conditions under which fires will crown soon after starting and, second, when large going fires will crown.

In many regions, the phenomenon known as spotting is a major factor in fire control. This needs analysis in the same manner. It is inconceivable to me that such questions as these can be answered except by study of going fires. Some of this is now under way but altogether too little. Many phases of fire investigation can and should be done by laboratory methods but it is clear that field study of going fires is the most certain method of making all the laboratory and forecast work usable and hence valuable.

Concurrently with this is needed additional emphasis on localizing of forecasts. It is important to know that in northern Idaho fire conditions will become more critical, but the man charged with protection on a particular watershed wants to know how reliable the forecast is for his particular territory, how north and south slopes will differ in hazard and similar details. The work now under way is tending

toward just such information and should be prosecuted aggressively.

So far the efforts at long term predictions have been decidedly timid and naturally so. In all regions, certain seasons are easy and others extremely difficult. We know in general that amount and distribution of spring precipitation is an important measure of the fire conditions of following months. But no one has made even an effort to study the cumulative effect of a series of years of subnormal precipitation such as we have had in California. It would seem that such an analysis might well lay the foundation for a better understanding of the general character of fire seasons and leave the sun spots to those chosen few who understand the Einstein theory.

For, difficult as it is to meet the unexpected emergency of a single fire that goes bad, it is infinitely more difficult to meet a season that for weeks or months is critical. With only a few bad fires, it is always possible to rush leaders, men, equipment to the scene. But with critical conditions simultaneous over a wide region, an adequate campaign can not be organized on the spur of the moment. So, besides more detailed study of going fires, future research should by all means seek the basis of prediction for the critical season. It is idle to ignore the fact that until the emergency fire season can be met successfully, the whole structure of forestry, at least in the most productive forest regions of the West, is on an unstable foundation.

It is axiomatic that a comprehensive research program includes detailed and searching investigations of the laws of combustion and the characteristics of different fuels. A very large part of this necessary ground work is susceptible of laboratory attack. The recent beginning in interesting trained physicists in the problem is a promising step in the right direction.

But the information necessary to apply these results, valuable as they will be, cannot be obtained in the laboratory. As the problem actually exists in the woods, we have a multitude of fuels in each important cover type. Given a going fire, which of these are the critical fuels? Which determine whether a fire will crown, whether it will spot? These and similar questions must depend on much more thorough analysis of the behavior of fuels in going fires. In one type of cover, it may be the lichens that are the critical fuel. In another, it may be down logs and snags. In another, it may be fireweed and fern. In another, it may be the litter. Systematic study of this whole field should receive at least as much attention as the laboratory investigations of combustion.

It is no doubt dangerous to attempt even this much forecast of probable future trends of weather and fire research. Some unexpected discovery, as, for example, in the field of static as a basis for prediction, may alter the entire outlook. But in the main outlines, the needed research seems fairly well indicated. The principal immediate requirement is for the active interest and support of the agencies charged with the actual job of fire control in the research work we know is needed. At least, in the heavy fire regions of the West, the whole fire control job is on an inadequate basis. Perhaps no part of the attack on the tremendously critical fire problem is less adequate than that of fire research.

CURRENT LITERATURE

Compiled by Helen E. Stockbridge, Librarian, U. S. Forest Service

LIST FOR FEBRUARY, 1927

(Books and periodical articles indexed in library of U. S. Forest Service)

Forestry as a Whole

Proceedings and reports of associations, forest officers, etc.

Congrès forestier international de Grenoble. Le problème forestier: travaux du Congrès forestier international de Grenoble, 22-30 Juillet 1925. 586 p. Paris, Les presses universitaires de France, 1926.

India—Jammu and Kashmir—Forest dept. Progress report on forest administration, 1925-1926. 96 p. pl., diagrs. Srinagar, 1926.

Oregon—State board of forestry. Sixteenth annual report of the state forester for the year ending Dec. 31, 1926. 54 p. il. Salem, Oreg., 1927.

Schlesischer forstverein. Jahrbuch für 1926. 223 p. Breslau, 1926.

South Australia—Woods and forests dept. Annual progress report upon state forest administration for the year 1925-26. 8 p. Adelaide, 1926.

Vermont—Commissioner of forestry. Biennial report for the term ending June 30, 1926. 72 p. pl., map. Montpelier, 1926.

Forest Aesthetics

Trelease, W. Plant materials of decorative gardening: the woody plants. 3d edition, revised. 188 p. Urbana, Ill. Pub. by the author, 1926.

Woodward, M. The new book of trees. 310 p. illus. London, A. M. Philpot, ltd., 1926.

Forest Education

Forest schools

Yale forest school. Catalogue, 1926-1927. 30 p. New Haven, Conn., 1926.

American forest week

United States—Dept. of agriculture—Forest service. Forestry facts: American forest week, April 24-30, 1927. 16 p. Wash., D. C., 1927.

Forest Legislation

Brazil—Ministerio da agricultura, industria e commercio—Serviço florestal. Decreto n. 4.421, de 28 de dézembro de 1921 crêa o Serviço florestal do Brasil: decreto n. 17.042, de 16 de setembro de 1925 dá regulamento ao Serviço florestal do Brasil. 22 p. Rio de Janeiro, 1926.

Forest Description

Cunningham, R. N. and others. Montana forest and timber handbook. 162 p. illus., diagrs. Missoula, Mont., 1926. (State university of Montana studies no. 1.)

Rafalski, J. Lasy i les'nictwo w Stanach Zjednoczonych Ameryki Pólnocnej: forests and forestry in the United States of North America. 178 p. illus., map. Warszawa, 1926.

Forest Botany

La Rue, C. D. The hevea rubber tree in the Amazon valley. 70 p. illus. Wash., D. C., 1926. (U. S.—Dept. of agriculture, Dept. bulletin no. 1422.)

Mowry, H. Palms of Florida. 54 p. illus. Gainesville, 1926. (Florida—Agricultural experiment station. Bulletin 184.)

Pittier, H. El estudio de los productos forestales en Venezuela. 44 p. Caracas, Tipografia Americana, 1927. (Boletin del Museo comercial de Venezuela, vol. 1 no. 1.)

Tozawa, M. Methods of hastening germination of tree seeds. 33 p. tables. Keijyo, Japan, 1926. (Bulletin of the forest experiment station, no. 5.)

Forest Influences

Japan—Ministry of agriculture and forestry—Dept. of forestry. Report on the work for the regulation of torrent. 12 p. pl. Tokyo, 1926. (Photostat copy.)

Forest Investigations

Forest experiment stations

Finland—Forstvetenskapliga försöksanstalt. Meddelanden, 10. 448 p. illus., pl., diagrs. Helsinki, 1926.

Holland—Rijksboschbouwproefstation. Mededeelingen, deel 2, afl. 3. 92 p. pl. Wageningen, 1926.

Silvical Studies of Species

Mattoon, W. R. Loblolly pine primer. 38 p. illus. Wash., D. C., 1926. (U. S.—Dept. of agriculture. Farmers' bulletin no. 1517.)

Forest Mensuration

Reinhold, G. Die bedeutung der gesamtwuchsleistung an baumholzmasse für die beurteilung der standorts—und bestandsgüte. 114 p. diagrs. München, 1926. (Bavaria—Staatsministerium der finanzen—Ministerial forstabteilung. Mitteilungen, heft 18.)

Forest Protection

Fire

Clearwater timber protective association. Nineteenth and twentieth annual reports, 1925-1926. 48 p. Orofino, Id., 1926.

Connecticut—State park and forest commission. Connecticut's forest fire problem: report on the state-wide forest fire conference held at Hartford, Conn., June 24, 1926. 16 p. illus., diagr. Hartford, Conn., 1926.

Forest Administration

Connecticut forestry association. State forests and parks: a dividend paying investment for Connecticut. 31 p. illus., maps, diagrs. New Haven Conn., 1927. (Publication no. 17.)

Corporazione forestale Italiana. Fascismo e selvicoltura. 40 p. illus. Roma, Tipografia ditta F. Pallotta, 1926.

Mawson, D. Some aspects of forestry in South Australia. 30 p. Adelaide, S. A., The Hassell press, 1925.

Forest Utilization

Forest by-products

Priest, G. H. Naval stores: production, consumption and distribution. 39 p. Wash., D. C., 1927. (U. S.—Dept. of commerce—Bureau of foreign and domestic commerce. Trade information bulletin no. 454.)

Wood Technology

Fairchild, I. J. Holding power of wood screws. 28 p. illus., diagrs. Wash., D. C., 1926. (U. S.—Dept. of commerce—Bureau of standards. Technologic papers, no. 319.)

Forsaith, C. C. The technology of New York state timbers. 374 p. illus., diagrs. Syracuse, 1926. (New York state college of forestry, Syracuse university. Technical publication 18.)

Stillwell, S. T. C. The movement of moisture with reference to timber seasoning. 29 p. illus., diagrs. London, 1926. (Great Britain—Scientific and industrial dept.—Forest products research. Technical paper no. 1.)

Auxiliary Subjects

Natural resources

Canada—Dept. of the interior—Natural resources intelligence service. Canada as a national property. 75 p. illus., maps. Ottawa, 1926.

New York state fish, game and forest league. Report, 62d annual convention, 1926. 20 p. Syracuse, N. Y., 1927.

North Carolina—Dept. of conservation and development. Biennial report, July 1, 1924 to June 30, 1926. 48 p. Raleigh, 1927.

National parks

National parks association. Bulletin 52. 20 p. illus. Wash., D. C., 1927.

Periodical Articles

Miscellaneous periodicals

American journal of botany, Jan. 1927.—The bitternut hickory, *Carya cordiformis*, in northern Minnesota, by A. M. Johnson, p. 49-51.

American paint journal, Feb. 14, 1927.—Technical study of wood painting practice, by F. L. Browne, p. 20-8.

American Scandinavian review, Feb. 1927.—Forestry, by J. H. Allison, p. 109-10.

Bulletin of the Pan American union, Mar. 1927.—Tropical hardwoods with special reference to their uses in American industries, by G. P. Ahern, p. 219-27.

Chemical and metallurgical engineering, Dec. 1926.—Production of synthetic lumber from mill scrap, by A. H. Johnson, p. 732.

Gardeners' chronicle, Jan. 27, 1927.—Pinus laricio, the Corsican pine, by C. C. Rogers, p. 68-9.

Gardeners' chronicle of America, Dec. 1926.—Reliable standards in tree surgery, by C. J. Toner, p. 344, 348.

House and garden, Dec. 1926.—World's ten most useful trees, by E. H. Wilson, p. 96-7, 150, 154.

House beautiful, Dec. 1926.—Shade trees: their care and protection, by C. F. Greeves-Carpenter, p. 768-70.

Industrial and engineering chemistry, Feb. 1927.—American tung tree culture, by H. A. Gardner, p. 266; Oxidation and hydrolysis of light wood oils, by P. O. Powers and others, p. 306-8.

Journal of the Society of chemical industry, Dec. 31, 1926.—Effect of acids on the mechanical strength of timber, by E. A. Alliott, p. 463-6.

National wool grower, Feb. 1927.—National forest grazing fee conference and decision, p. 13-15.

New Zealand journal of agriculture, Jan 20, 1927.—Forestry nomenclature, with special reference to the eucalypts, by J. H. Simmonds, p. 8-12.

Oil, paint and drug reporter, Jan. 27, 1927.—Scientific turpentining, by E. Gerry, p. 90, 92.

Phytopathology, Dec. 1926.—Phomopsis juniperovora and closely related strains on conifers, by G. G. Hahn, p. 899-914.

Producer, Feb. 1927.—Foxtail, a menace to live stock, by W. C. Barnes, p. 3-5; Secretary Jardine settles forest-fee controversy, p. 9-10, 13-14.

Railway age, Jan. 29, 1927.—Wood preservation and utilization in Europe, by G. M. Hunt, p. 379-80.

U. S. Dept. of agriculture. Official record, Feb. 9, 1927.—Big Alaska pulpwood sales are advertised, p. 1, 3.

U. S. Dept. of agriculture. Official record, Feb. 16, 1927.—Grazing-fee question settled by Secretary, p. 1, 6.

Trade journals and commerce reports

Automotive manufacturer, Jan. 1927.—Wood finishing: a glance ahead, by F. L. Browne, p. 9-11.

Barrel and box, Feb. 1927.—Actual facts revealed by laboratory tests, by D. L. Quinn, p. 15-17; The importance of the fruit package industry and timber conservation in the state of Illinois, by R. B. Miller, p. 18-20.

Engineering news-record, Feb. 24, 1927.—Railroad tie specification and tie treatment, by W. F. Goltra, p. 309-10.

Forest products bulletin, Dec. 1926.—Standardization of mine timber, by R. E. Krape, p. 1-4; Necessary safety precautions in the operation of portable sawmills, by T. R. Snyder, p. 18-22; Standardization of anthracite mine timber, by A. C. Neumueller, p. 27-31; Lumber standardization, by R. D. Garver, p. 42-8.

Hardwood record, Jan. 10, 1927.—Swedish saw mills, by G. F. Cosgrove, p. 18-19, 22, 24; Philippine operations both interesting and modern, p. 35-6, 40, 42.

Mechanical engineering, Dec. 1926.—Value of paint primers in protecting wood, by M. E. Dunlap, p. 1457-9.

Mississippi valley lumberman, Feb. 25, 1927.—The truth about the forest situation, by A. A. Hood, p. 22.

Southern lumberman, Feb. 19, 1927.—Walnut steering wheels, by G. N. Lamb, p. 50.

Timber trades journal, Jan. 22, 1927.—Constructional timbers, by J. L. Crawford, p. 243-4.

Timber trades journal, Feb. 12, 1927.—Oaks: their distinguishing features, by J. P. Fraser, p. 473-5; Cypress: its history and uses, by W. B., p. 476.

Timberman, Feb. 1927.—Private forestry, by J. B. Woods, p. 37-8; Insurance on felled timber, by W. H. Gibbons, p. 38-9; Air chambers for steam fire-pumps, by G. L. Drake, p. 42; Use of explosives in logging, by K. A. Merriman, p. 90, 92; Re-logging for pulpwood in the douglas fir region, by A. H. Hodgson, p. 98-101; Methods of obtaining wood cellulose, by C. L. Thompson, p. 102; Forest service offers Alaska pulp timber, p. 103-5; Tractor damage to reserved trees and reproduction: how regulated, by J. R. Berry, p. 146-9; Improving timber bucking technique, by A. M. Koroleff, p. 154; Trend of the wood preserving industry, by H. S. Sackett, p. 158; Silvicultural investigation in B. C., by J. L. Alexander, p. 162-6; B. C. forest administration, by P. Z. Caverhill, p. 168; Why care in selection of cross ties, by J. Foley, p. 170-4; Compulsory slash disposal in Montana, by D. Skeels, p. 178-82; Static removal on ground phone lines in forests, by R. B. Adams, p. 190-1.

U. S. commerce report, Jan. 31, 1927.—United Kingdom lumber market outlook, by A. E. Boadle, p. 289-91.

U. S. commerce report, Feb. 14, 1927.—Lumber exports during 1926, by A. Marlowe, p. 416; Swedish pulp and paper market trend, by E. A. Kekich, p. 424-5.

U. S. commerce report, Feb. 21, 1927.—Adverse conditions in Norwegian pulp and paper industries, by H. Sorensen, p. 476-7; Production of timber in Japan, by E. A. Selfridge, p. 482.

U. S. commerce report, Feb. 28, 1927.—Porto Rico's lumber purchases, by J. R. McKey, p. 548-9.

Veneers, Feb. 1927.—Veneers from thuya burls, by C. D. Mell, p. 19-20; More veneers used in radio plants, by F. J. Koch, p. 22-3.

West Coast lumberman, Feb. 15, 1927.—Text of forestry act now before state legislature, p. 24; Specific facts: valuable information on result of years' experimental studies of pondosa pine, by A. Hermann, p. 36, 40.

Wood preserving news, Feb. 1927.—Building a levee in the Mississippi, p. 20-5.

Wood working industries, Feb. 1927.—A further improvement in bending pans, by T. R. C. Wilson, p. 24-6.

Forest journals

Allgemeine forst- und jagdzeitung, Jan. 1927.—Systembildung und waldbauliche freiheit, by C. Wagner, p. 1-18; Zur waldbesteuerung, by H. Weber, p. 30-5.

American forests and forest life, Mar. 1927.—How nature overcomes difficulties, by T. S. Hansen, p. 145-7; Secretary Jardine announces grazing decision, p. 147-8; Clifford Robert Pettis, p. 149; Gardening against a background of trees, by C. A. Byers, p. 157-64; How and when to prune, by H. S. Bartlett, p. 165; Annual meeting at New Haven gives forestry new force, p. 166-70, 173-4; Uncle Sam saves the longhorn from extinction, by W. C. Barnes, p. 171; Scouts plant Roosevelt trees, p. 192.

Anthracite forest protector, Jan.-Feb. 1927.—Forests and the anthracite region, by R. Y. Stuart, p. 3-4; Annual report of the secretary of the Anthracite forest protective association, p. 5-14; Free trees for forest planting, p. 16, 31; "Just a forest ranger," by T. Kidd, p. 19, 31.

Australian forestry journal, Nov. 15, 1926.—The Norfolk Island pine, p. 284-8; Forest insects no. 27: wood-eating ants, by W. W. Froggatt, p. 289-91; Application to the maritime pine of the various processes of manufacture of paper pulp, p. 302-5.

Centralblatt für das gesamte forstwesen, 1926.—Die forstwirtschaft Finnlands, by F. Heske, p. 204-22, 294-304, 321-37; Hochwurzeln an waldbäumen, by E. Wichmann, p. 350-3.

Forstarchiv, Jan. 1, 1927.—Die synthetische gewinnung der produkte der holzdistillation und ihre wirtschaftliche auswirkung, by E. Wedekind, p. 1-4.

Forstarchiv, Jan. 15, 1927.—Forstwirtschafts-politik, by H. Lemmel, p. 17-22; Vom diesjährigen auftreten des fichtennestwicklers (Tortrix tedella) im Harz, by Allers, p. 22-3; Die "Rinco" baumfäll-und ablängemaschine, p. 26-8.

Forstarchiv, Feb. 1, 1927.—Forststatistisches aus Baden, by J. Graf, p. 33-6; Zur einmischung nutzholzmehrender holzarten in die buchenver jüngungen auf kalkböden, by Berner, p. 36-8.

Forstwissenschaftliches centralblatt, Dec. 15, 1926.—Der wuchs der eiche in abhängigkeit von dem gewicht der eicheln, by G. Eitingen, p. 845-63.

Forstwissenschaftliches centralblatt, Jan. 1, 1927.—Die urproduktion des waldes in ihren beziehungen zur streuzersetzung und waldmoor, by Weinkauff, p. 1-15; Stocküberwallungen, by Fabricius, p. 19-26; Aus dem forstlichen versuchswesen Russlands, by M. Tkatschenko, p. 27-35.

Forstwissenschaftliches centralblatt, Jan. 15, 1927.—Dänische und deutsche forstwirtschaft, by K. Vanselow, p. 49-63; Das mittlere alter ungleichaltriger bestände, by W. Tischendorf, p. 63-6.

Illustrated Canadian forest and outdoors, Feb. 1927.—A great gathering at forestry convention, p. 65-70; Ontario provides 7,000,000 trees for planting, p. 94; How to handle groups of young trees, by A. H. Richardson, p. 100; The wooden world, by G. P. Melrose, p. 103-5; Ontario's fire experience in 1926, p. 115.

Indian forester, Jan. 1927.—The railways and the forests, by R. G. Marriott, p. 1-15; Special growth of trees, by F. C., p. 15-18; An interim report on the progress of investigations into the origin of twisted fibre in Pinus longifolia Roxb., by H. G. Champion, p. 18-22; The French method of 1883 and its modifications, by M. D. Chaturvedi, p. 22-5; Durability tests of Malayan and other timbers, by F. W. Foxworthy, p. 25-33; Greenheart, by B. R. Wood, p. 54-6.

Journal forestier suisse, Feb. 1927.—La fidonie du pin en Basse-Alsace, by A. Barbey, p. 29-35.

Journal of forestry, Feb. 1927.—The old order changeth in Michigan, p. 121-2; Forestry and the Society, by S. T. Dana, p. 123-8; The Society, by R. Y. Stuart, p. 129; Better seeds, better trees, by C. G. Bates, p. 130-44; The forest trust: a device for the advancement of forestry in the United States, by P. P. Wells, p. 145-52; Improvement cuttings: their role in American forestry, by M. H. Moyer, p. 153-6; The line-plot system, its use and application, by W. M. Robertson, p. 157-63; Accuracy of methods in estimating timber, by R. H. Candy, p. 164-9; Travels and travails in forestry, by C. A. Schenck, p. 170-7; Volume production in forestry literature, by R. Marshall, with comment by H. H. Chapman, p. 178-80; A method for rapid surveys of vegetation, by W. C. Lowdermilk, p. 181-5; Forestry by private owners does pay, by E. Wilson, p. 202-3; Society affairs, p. 206-49.

Revue des eaux et forêts, Jan. 1927.—La grande misère du chêne dans nor forêts françaises, p. 1-3; Recherches rétrospectives sur les insignes et les marques distinctives de l'Administration des eaux et forêts, by L. Lavauden, p. 4-10; Le mouvement forestier à l'étranger, by G. Huffel, p. 11-22.

Société forestière de Franche-Comté. Bulletin trimestriel, Dec. 1926.—Le concours-exposition des Landes, by P. Buffault, p. 465-78; Concours d'améliorations pastorales et forestières, by Lachaussée, p. 486-8; L'aménagement sylvo-pastoral appliqué dans les pâturages boisés du Jura, by A. Barbey, p 488-94; Branches, noeuds et mode de traitement, by A. Schaeffer, p. 495-500.

Thardanter forstliches jahrbuch, 1926.—Jubiläumsfeier der forstlichen hochschule zu Tharandt, by P. Jaehn, p. 354-403; Der kiefernpollenflug in Kopenhagen am 25. Mai 1804, by A. Oppermann, p. 404-8.

University of Washington, Forest club quarterly, Nov. 1926.—The marine borer problem on the Pacific coast, by R. C. Miller, p. 5-11; The pedigree of a forest fire, by R. E. Conway, p. 12-21; Our cut-over lands, by E. G. Cheyney, p. 22-3.

REVIEWS

A National Program of Forest Research. Prepared by Earle H. Clapp as the Report of a Special Committee on Forest Research of the Washington Section of the Society of American Foresters, consisting of R. C. Hall, A. B. Hastings and E. H. Clapp. Published for the Society of American Foresters by the American Tree Association, Washington, D. C., November, 1926. Pages IX & 232.

This comprehensive report on the present status, the needs, and the opportunities of forest research is a significant contribution to the literature pertaining to forestry in America. In concise style it brings out the basic necessity for research in all branches of forestry; enumerates with illuminating comments a multitude of specific points concerning which exact, scientific knowledge is required; and lists the agencies in the United States that are engaged in forest research. Then, under the caption of "The agencies needed in a national program," pp. 173-191, it sets forth a ten-year national budget, with a series of pertinent recommendations as to more research by industrial agencies, state organizations, endowed institutions, and the federal government. Then follow specific recommendations as to a national structure of research organizations and a summary of conclusions, stressing the essential unity of forest research.

An appendix of twenty-four pages contains the draft of an organic act designed to create a unified program for forest research in the U. S. Department of Agriculture, and a useful list of the organizations engaged in forest research in other countries. In this are summarized under forest experiment station or institute the chief lines of work that have characterized that agency and that are being carried on now. In all 26 countries are represented, distributed throughout the world.

The major credit of preparing this report belongs to Earle H. Clapp, Head of the Branch of Research, U. S. Forest Service. In addition to the other members of the Committee, named above, a considerable number of other persons, mainly foresters in the U. S. Forest Service, gave assistance in the preparation of the report, as is stated in a note of acknowledgement. Some of them contributed complete sections, as Donald Bruce, Drs. L. F. Hawley and J. D. Rue, Aldo Leopold, C. G. Bates and W. N. Sparhawk.

Through the courtesy of the American Tree Association (and it may be surmised the personal interest of Mr. Charles Lathrop Pack) the report was published without expense to the Society. This is an example of helpful cooperation that deserves the appreciation of all

foresters, for failing this outside aid the manuscript of the report might have been a long time in getting into print. The book is on good paper, clearly printed, and so far as the writer has observed, absolutely free from typographic errors.

In a brief introduction it is stated that the suggestion that led to the appointment of the Special Committee on Research in the Washington Section, came from Col. W. B. Greeley in an address made in November 1924. Urging action to stimulate and correlate forest research in the United States, he adduced four reasons:

1. The outstanding importance and urgency of the forest problem of the United States; 2. The basic place of research in the solution of this problem; 3. The general failure to date to recognize the magnitude and complexity of the research task and provide for it; and 4. The consequent need for leadership by professional and scientific organizations as a means to concerted national action.

With these beacons for its guidance the Committee has undertaken to set up a national program of objectives, both in research problems and in the organizations required for their solution. It has done its task well. The resulting report is a storehouse of information as to why and where research in forestry should be done. But it is vastly more than that. Although detailed and exhaustive in its enumerations, and in places concerned with details that might easily have become submerged in technicalities, the text throughout preserves a clear and lucid style that makes one wish to read on and on, with sustained interest. It is a live presentation of a vital issue. In that to Mr. Clapp apparently fell the task of coordinating and preparing the report for publication, it is only just that especial commendation, and thanks, be given him on the outcome.

The introductory chapter, including the sections, "The Forest Problem of the United States" and "Is Forest Research Needed in the Solution," pp. 2-21, is a clear cut statement of the situation as it exists today, with cogent reasons why research will help us to discover the solution. The conclusion is inescapable that research is not only needed, but absolutely demanded in every branch and subdivision of forestry. There may not be much that is really new in most of this chapter, but it sums the case up in a forceful way that shows the essential unity and inter-dependence of the whole field. What is new, however, is the final recommendation, the argument for a national program, which with what follows at the end of the volume, is of course the crux of the whole matter under discussion.

The major part of the report is necessarily and properly devoted to a statement of the Research Problems of a National Program, pp. 22-147. Under highly sub-divided parts and sub-sections, the entire field of forestry and the closely related sciences seems to have been covered. The Committee, however, modestly disclaims doing more than presenting "those problems of greatest importance, in the light of our present knowledge, in a suggestive rather than a detailed way."

It is not possible, nor would it be pertinent in a review like this, to attempt to analyze the vast number of projects that are suggested and touched upon in this comprehensive, but nevertheless concise summary. If anything has been overlooked the attitude of this reviewer would be to direct attention to the very many other problems that are enumerated. These certainly give opportunity for detailed investigation of many years' duration by a far larger corps of research men than is yet in sight. If Clapp has overlooked anything, it is certainly not in any major line of research.

There is, however, one feature of this compilation that seems to the writer to strike a jarring note. This is the terminology used in the captions of some of the several divisions, particularly those that head the list. Back in 1917, in the first issue of the JOURNAL OF FORESTRY*, appeared a terminology of certain terms used in forestry with the idea that the definitions there given should be recognized, by common consent, as constituting the official usage of the Society of American Foresters.

In that list of terms used in a technical sense there appears, p. 81, after the definition of Forestry, the statement: "The main branches of forestry are Forest Policy, Silviculture, Forest Economy or Forest Management (including forest mensuration, organization or regulation, administration and finance), Forest Protection and Forest Utilization." Forest management is defined, p. 78, as "the practice or application of forestry in the conduct of the forest business."

To those members of the Society who have endeavored consistently to follow what they have assumed to be the approved usage, it is frankly a bit disconcerting to come upon such a statement as the following, on page 23 of the report under review: "Forest management is used in a somewhat restricted sense to include silvics, or the fundamental science that underlies the growing of forests, silviculture proper, or the actual growing of timber crops, and forest mensuration, or the

* Forest Terminology. Journal of Forestry, Vol. XV-No. 1, Jan., 1917, pp. 68-101.

determination of form, volume, growth and yields." Still more so is the phase, on p. 24, "Silvics, or forest botany, like all other branches of biology must," etc. The context makes the meaning perfectly clear, but since when have silvics and forest botany become synonymous terms?

It is in no spirit of carping criticism that this point is raised here. For if a committee of one of the leading Sections of the Society departs radically from the supposedly accepted standards of the Society as to terminology, how can we hope to arrive at anything like a precise use of technical terms within the Profession of Forestry? The probable explanation would seem to be, in that so many of those concerned with this report are Forest Service men, that the administrative signification of the term Forest Management in use in the Forest Service outweighed the technical meaning that had earlier been assigned to it by the Society. May the hope be expressed here that some day the Society will escape from the morass of a confused terminology.

In the third main division of the report, the list of research agencies, with their chief activities, should prove useful for other purposes beside the one for which it is compiled. It is of course not the first of such enumerations, as the Committee is careful to point out in the introductory paragraphs of the report. It is a helpful compilation, as is also the summary of forest research agencies in other countries, that appears in the appendix. The latter was prepared for the report by Mr. W. N. Sparhawk.

To one who has not had occasion to check up, or personally to come in contact with research work in forestry, the number of agencies already in the field, and the scope of their investigations, must be illuminating. But when one considers the great range of topics about which we as yet have so little exact knowledge, the necessity for strengthening the body of research workers, both as to personnel and equipment, becomes the more apparent.

The real meat of the report, however, is found in the latter part of the book, especially the sections headed "The Agencies Needed in a National Program," pp. 173-187, and "Conclusion," pp. 192-207. Here are given the recommendations of the Committee, backed up by cogent arguments why they should be given heed.

On the basis of a ten-year national budget,—a decade being chosen as a good arbitrary initial unit,—the Committee sets forth what in its judgment might and ought to be done by industrial agencies, state organizations, the federal government, and endowed institutions. Figures are quoted to show that the present annual expenditure from

all these agencies collectively "probably does not exceed $2,600,000." For comparison the expenditure by all agencies for agricultural research is from $20,000,000 to $25,000,000 annually; for industrial research of all kinds, $75,000,000.

If these outlays are proving worthwhile,—and they would not be made if they were not so considered,—the Committee holds it "not unreasonable to look forward to regularly increasing annual expenditures in forest research, which at the end of a decade would reach from $9,000,000 to $12,000,000." Why? Because research is demanded on "problems involving one-fourth of our total land area, the permanence of our fourth group of industries, the supply and effective utilization of one of our most important commodities, and of a number of lesser commodities."

In some detail it is then shown how the amount needed might be allocated. As to totals the distribution is as follows:

Industrial agencies	$2,000,000	to	$3,000,000
All state agencies	2,000,000	to	3,000,000
The federal government	3,000,000	to	4,000,000
Endowed institutions	2,000,000	to	2,000,000
	$9,000,000	to	$12,000,000

The two outstanding and detailed recommendations of the Committee are for a Forest Research Institution and for an Organic Act for the U. S. Department of Agriculture for forest research. To round out the national structure of forest research organizations, serve to increase the efforts of all other agencies, and as a stimulus to new work, it is believed that an endowed Forest Research Institution warrants the most serious consideration. In organization it could profit by the experience of the Carnegie Institute, the Mellon Institute, and the Boyce-Thompson Institute. It should especially devote itself to long term fundamental problems, under a well rounded out program of coordinated attack. It could by subsidies to other agencies stimulate work now in progress. It could bring about close integration of fundamental investigations, its chief objective, with the more local projects of other organizations. "Such a program could not be adequately undertaken with an annual income of much or any less than $1,000,000. An endowment alone would meet the requirements."

The other recommendation, on Organic Act for the U. S. Departmen of Agriculture, gets down to an itemized estimate of allotments for specific purposes. The total for which authorization is suggested for annual expenditure is $3,150,000. The items are as follows:

For the Forest Experiment Stations, Forest Service	$1,000,000
Forest Pathology	225,000
Forest Entomology	225,000
Forest Fire Meteorology	50,000
Forest Products Laboratory Work	1,000,000
Tropical Woods	50,000
Grazing Research	275,000
Wild Forest Life Studies	75,000
Forest Economics	250,000
	$3,150,000

To this is added a lump sum of $3,000,000 for a nation-wide forest survey, to be expended through non-reverting, annual allotments of $250,000.

It may be of interest in this connection to mention that on March 3, 1927 there was introduced in the 69th Congress, at the very end of the second session, a bill, H.R.17406, by Representative John McSweeney of Ohio, that very closely follows the draft given in the appendix of the Committee's Report, except that it raises the items for Pathology and Entomology to $250,000 each, and that for Wild Forest Life to $90,000. The total annual appropriation authorized in the McSweeney bill is $3,215,000, plus a total of not to exceed $3,000,000, in annual installments of $250,000, for a comprehensive survey of the present and prospective requirements for timber and other forest products in the United States in cooperation with the states and other agencies. This bill was referred to the Committee on Agriculture and ordered to be printed. Copies are therefore easily to be obtained.

The introduction of a bill in Congress does not, of course, insure its immediate enactment into law. It will probably require a long campaign of education to make the public understand why such large sums are required for research in forestry. It may take an equal or longer time to find a donor or group of donors to endow a Forest Research Institution. To put any such program into effect will also require very many more trained men than are now available, or indeed are even in sight.

It *is* a big program. But why not? Forestry in the United States is a big issue; one of sufficient importance to justify all that is here asked, and more. Has not the President of the United States, in his Forest Week Program for 1927, just reiterated the fundamental necessity for right care and wise use of American forests, in words much like those of his predecessors? "It is my belief that no other of our internal problems is of greater moment than the rehabilitation of our forests, now so hopefully begun but needing the strong support of our collective will and intelligence."

In making its report and submitting its recommendations the Committee of the Washington Section has done something of which all members of the Society of American Foresters have reason to be proud. At last the American people have definitely before them a logical and reasonable program, backed by a statement of reasons why it should be adopted so clearly and concisely expressed as to leave no room for misunderstanding.

The piece-meal method by which our forest experiment stations and other research activities in forestry have up to now been supported, is a sad commentary on the vaunted ability of the American people to realize the importance of a problem that involves nearly as much of our land area as that occupied by productive agriculture. As the Committee itself points out in the conclusion, where is admirably summed up the essential unity of forest research, "the owners of forest lands, the forest industries, the general public, and even the foresters themselves must be brought to see the great opportunity that is offered by forest research, and to see the futility of depending upon other means." "The situation calls unmistakably," for the development of forest research as a big national undertaking," on a scale commensurate with the development of agricultural research, and with the movements to acquire public forests, prevent forest fire, and to bring about the practice of forestry on privately owned lands.

The report on A National Program of Forest Research points the way. It is an incentive and a challenge to all American foresters to do their utmost to help to make this vision come true.

RALPH S. HOSMER

Introduction to Production Economics. By John D. Black, Henry Holt and Company, Publishers, New York, 1926.

The developments following the World War have brought about a great deal of confusion and disorganization in our economic life and a similar confusion and disorganization in our conception of economics. Until the war economists were leading a quiet life. The conservatives were satisfied with things as they were, the liberals were patching up the economic organism by various devices such as workingmen's compensation acts, employment bureaus, safety laws and so on, while the socialists, secure in their faith in the Marxian theories, were devoting their time to the program "minimum," in other words, to immediate improvements and dreaming of the coming social revolution to carry out their program "maximum" or the complete realization of the Marxian program.

The grandiose events of the World War, the advent of Bolshevism, the organizing efforts of the warring governments in industry and agriculture—followed by the tremendous depression of 1921 have disturbed the "Gemühtlichkeit" of the various wings of economic thought. Socialism was no more a distant dream—it had received a practical application in Russia. The traditional American individualism was sorely disturbed. An era of "re-valuation of all values" was inaugurated and an influx of new ideas, new conceptions and new ambitions followed in its wake. Economics took on a scientific coloring. Search for facts became the order of the day. Great research agencies (partial and impartial) were formed. Objectivity based on statistics became the motto and the hope of the economist. The need of orientation amid the wealth of statistical material brought forth led to a pronounced trend toward theoretical speculation and elucidation of principles.

These tendencies seem to be reflected in the preface to Dr. Black's book, "Introduction to Production Economics." The preface stresses the importance of objectivity and points out that most of the bad economic thinking in the world is due to a failure to comprehend elementary economic relationships which statement can not be interpreted otherwise than as assigning the cause of this failure to a misunderstanding of principles conditioning economic relationships.

There are principles and principles. The greater part of Dr. Black's book is devoted to a discussion and exposition of principles of production organization and his treatment of this subject can be considered as a distinct contribution to the teaching of this particular phase of production economics. However, the picture is far from being complete because of the insufficient conception of the word "principle" when confined to a narrow sector of the field of economics. The real principles of production organization can be understood only if sufficient attention is given to those broader principles which lie outside of production economics proper but whose action modifies and even blocks the free operation of the forces of production. These broader principles which relate to the method of distribution and the profit motive in production are either skimmed over or are not given proper consideration by Dr. Black as can be seen from the following quotation from the text (page 21):

"The labor movement and the growth of socialism has greatly stimulated interest in the problem of distribution. It has been pointed out frequently of late, however, that if all income, let us say, above three thousand dollars a year per person, in the United States were

pared off and distributed equally over the remaining population, less than a hundred dollars would be added to the income of each person. Obviously if the condition of mankind is to be greatly improved, some means must be found for increasing still further the per capita production."

Dr. Black evidently seems to think that unless we increase the productivity of the country the most ideal distribution of wealth will not improve the condition of mankind. This "obvious" truth might have passed unquestioned ten years ago but the truly miraculous increase of production during the war and the postwar depression which resulted from our inability to check this accelerated production upset the candor of Dr. Black's statement. It is regrettable that Dr. Black does not give an adequate amount of space to factors outside of the field of production which hamper the organization of production and which react adversely on the efforts to increase productivity. Such questions as absentee ownership in modern industry, unjust method of distribution, lack of purchasing power on the part of the consumer, stabilization of markets, should be given prominent space in any book dealing with production economics. Otherwise the student will not get an understanding of the action of the forces which retard production and decrease productivity.

Likewise a lack of completeness occurs in the treatment of the relation of production and consumption. Dr. Black points out that production is not an end in itself, that it is greatly influenced by consumption. However, in his review of this subject, Dr. Black again diverges from the fundamental relation in order to devote several pages to comparatively unimportant aspects of this relation.

In the quest for explanation of forces responsible for periodical business depressions more and more attention is being paid to the consumer's buying ability. J. H. Hobson, W. F. Foster, W. Catchings and a long line of others, both economists and laymen, are coming to recognize that the consumer's purchasing power must be given a prominent space in the explanation of phenomena relating directly to production. Every report of the U. S. Bureau of Agricultural Economics dealing with agricultural conditions stresses the importance of industrial conditions as they relate to the earning power of the consumers in relation to the possible or probable effective demand for farm products on the part of the city consumer. This important relation, which undoubtedly has a determining influence on the smooth working of productive forces, is not emphasized by Dr. Black whose analysis of

the relation between production and consumption resolves itself into a discussion of the minor aspects of this problem in so far as they relate to the subject of Home Economics.

The unwillingness to get away from the time honored physical concept in economics and the insistence on efficiency in a narrow sense which is exhibited by Dr. Black's treatment of the subject of production is largely responsible for the fact that the present day economic problems are not only far from approaching a solution but are not even crystallized in the minds of the vast majority of economists and laymen. This is particularly true of problems relating to agriculture and conservation.

Agriculture, it is admitted, is passing through a crisis unprecedented in the history of the country. The inability to market farm products at a price covering cost of production is a chronic disease alleviated from time to time by reduced plantings which usually follow in the wake of tremendous financial losses. Country bank failures, the number of bankruptcies among farmers and the official figures relating to farm incomes in the United States are the best proof of the fact that the situation in agriculture is not the result of temporary maladjustments between production and consumption as the efficiency economists including Dr. Black (page 909) believe, but is the result of an economic disease affecting not only agriculture but society as a whole and having its roots in the system of distribution in modern society. Farming has long since ceased to be self-sufficing. It stands in an intimate mutual relationship of dependence with all the other economic activities of society. Everything that affects adversely urban industry has an equal adverse influence on farming. When the majority of city workers do not earn enough to make a good demand for articles of consumption, when the buying ability of the city population is destroyed by widespread unemployment, the effective demand for farm products is necessarily curtailed and efficient production will not only not help matters but will make worse an otherwise bad situation.

To what extent productive processes are hampered by economic relations in modern society is illustrated by the problem of land utilization. It is an established fact that much of the land which is under cultivation at the present time should be put to some different use. At first sight this would seem to be purely a question of production. However, a closer analysis reveals that the present system of land utilization is the result of the action of historical and economic forces and that a more adequate system of land utilization is dependent upon cor-

rective measures looking towards a rearrangement of property relations in regard to land. A concrete illustration is afforded by the fact that originally much of the land acquired by individuals or corporations was taken up with a speculative purpose in view and in the subsequent settlement of such land rational use was subordinated to considerations of speculative profit. The system of land utilization which was brought about by this method of acquiring and settling land did not conform to the best interests of agriculture. The result is that the problem of proper land utilization is dependent for its solution upon such considerations as the ethical and economic justification of incomes arising out of speculative holdings of land and the question of the efficacy of the power of taxation for bringing about a more rational utilization of land.

It will be readily seen that these same problems are of paramount importance in the realm of forestry. As in the case of agriculture and industry the technique of production in forestry has attained a high standard of efficiency. If the problem of renovating our depleted forests were purely a question of making trees grow the solution would not present any obstacles. But the real problem in forestry is analogous, if not identical, with the major problem in agriculture—that of land utilization—and as in the case of agriculture its solution depends upon the action of forces operating outside of the sphere of production. This idea is well brought out by W. B. Greeley who in an article entitled "Economic Aspects of Forestry,"[1] shows that the question of reforestation is governed by a set of economic factors relating particularly to the question of relative costs. Thus the cost of producing wood, states Mr. Greeley, may be materially lessened by favorable forms of land taxation, and on the other hand, may be kept above the limits of practicable competition by either excessive taxes or methods of taxation ill adapted to a 50- or 75-year crop. Mr. Greeley further points out that the tendency in all countries and regions as wood becomes higher in price and more difficult to obtain is to develop taxation and other public policies designed to cheapen and encourage its production. After stating that forestry is at bottom a matter of economics in the use of land and the production of raw materials, Mr. Greeley points out that the aim of the Clarke-McNary forestry law is to clear the path for the economic forces behind timber growing by giving forest crops security from loss by fire and from inequitable burdens of taxation.

Mr. Greeley's insistence on the importance of such questions as

[1] "Journal of Land and Public Utilities Economics," April, 1925.

taxation in relation to reforestation shows that he has a clear vision of the real forces influencing economic phenomena, that he realizes that the center of gravity in the economic life has shifted from the questions of the mechanics of production to those forces which deal with the social, ethical and economic incentives influencing the actions of man. No substantial progress in the study of economics can be made until the majority of our economists follow the trail blazed by Mr. Greeley and a handful of professional economists who realize the significance of the fundamental change which is taking place in the economic life of the nation but whose voice remains as unheeded as the voice of a wanderer in a desert.

In concluding this review it should be stated that while Dr. Black recognizes the significance of some of the social and economic forces interfering with efficiency in production, his discussion of their action shows clearly that he underrates their importance. This is particularly striking when compared with the thoroughness and comprehensiveness of his treatment of the subject of production organization.

WM. KIRSCH.

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De Zandverstuivingen Bij Kootwijk In Woord En Beeld. By Dr. Ir. P. Tesch, E. Hesselink, and Dr. J. Valckenier Suringar. Utrecht, 1926.

This is a work published at Utrecht by the forest service of the Netherlands in 1926 (pp. 70). It consists of a series of exceptionally well reproduced photographs and a text. It deals with an area of 30,000 acres of wind-blown sand, located in the province of Gelderland, near the town of Kootwijk.

The introduction is written by E. D. van Dissel, superintendent of the government forest service. He points out that this is one of the largest and most interesting wind-blown sand areas in Europe, which has been for centuries a danger to the surrounding grazing lands for sheep and the agricultural districts. The land was acquired by the government in 1897. A large part has since been afforested and some of the area will be kept as a national park to save some of the typical geological formations and interesting flora of this district.

The geological structure of the area is discussed by Dr. Ir. P. Tesch, superintendent of the government geological service. The territory is built up of preglacial, glacial and fluvioglacial material. The altitude is 50 feet to 180 feet above sea level. The surface consists mostly of fluvioglacial material. At the lowest levels we find some

outcrops of the glacial and preglacial material. The fluvioglacial material is regularly stratified, the material consists of sand, fine to coarse grained.

Mr. E. Hesselink, superintendent of the government forest experiment station, writes on the origin, the expansion and the control of the drifting sand. The country slopes gently from east to west, the inclination being 1:250 to 1:750. The wind-blown area is partly intersected by strips of heath.

It is probable that before the aeolian action started the entire area was covered with heath and unequally distributed growth of oaks. The formation of the dunes is due to the fineness of the sand and the dryness of the soil. These aeolian sands or "Zanverstuivingen" are located in a shallow valley where the soil has been leached and an abundant amount of pan formation is present, which has greatly influenced the moving of the sand. As the formation of pan increased the soil became poorer, vegetation decreased and the soil tended to dry out rapidly above the pan formation. Under these conditions a slight injury to the ground cover by man or fire made the blowing of the sand possible. Two distinct types of wind-swept land are distinguished, (a) the original type, above the pan formation, (b) the secondary type which is adjacent to and caused by the original type. In the latter case sand has been blown over the bordering land and killed the vegetation, making the land an easy prey of the wind. Dunes 35 feet and higher have been formed. The pan formations have been exposed and stand up as table-like elevations a few feet higher. The dunes in several cases have blocked the free drainage, thus causing small lakes. The resulting rise in the water-table has brought partial re-vegetation of the wind-swept region.

A short discussion of the published material dealing with the "Zandverstuivingen" during the last 500 years, shows that already in 1532 the detrimental results of the heath fires were recognized and measures were taken to prevent the same. Prevention of heath fires, sand anchoring fences, resembling our snow fences, were the first means of controls employed. Later on afforestation was recommended and also the planting of *Calamagrostis arenaria* and *Hordeum arenarium.* A detailed map of the locality, two east-west profiles, several soil analyses and some statistics with respect to the area of the wind-swept land during different years, add much to the easier understanding of the situation. The largest area measured, called the "Aanstoter" or "Otterlosche zand," had an area of 510.95 hectares in 1810; in 1826

this had increased to 1,296 hectares; in 1840 to 1,617 hectares, but in 1843 it fell to 1,587 hectares, and by 1895 to 1,260 hectares. The figures show the rapid increase due to neglect during and after the Napoleonic wars.

Dr. J. Valckenier Suringar gives a detailed description of the flora of this district. He mentions two main types, the heath flora and the flora where the sand is still migrating. The heath flora consists mainly of *Calluna vulgaris* and *Erica tetralix,* algae, fungi, mosses and lichens are also present. *Pinus sylvestris* and *Juniperus communis* are characteristic of this region, besides these we find *Quercus robur, Salix aurita L.* and *Salix repens.* Several herbaceous plants are also mentioned but they all seem to occur in a rather dwarfed form. The grasses, however, outnumber the other plant species; very common are *Corynephorus canescens Pal. de Beauv., Festuca ovina L.,* and *Agrostis canina.*

The flora where the sand is in motion has only four plant species in common with the heath flora, these are the grasses: *Festuca ovina L., Festuca rubra L., Corynephorus canescens Pal. de Beauv* and *Agrostis canina L.,* besides these *Ammophila arenaria Lk.* is represented which can only exist in moving sand soil and does not occur in the heath flora. The five species occurring on the wind-blown area are discussed in great detail. The extreme difficulties under which they have to exist are: the moving sand which may uncover or bury the plants; the very loose upper layer of soil is exposed to great extremes of temperature in the summer; the subsoil is hard, wet and poor in mineral constituents and humus; during the summer the bright sunlight is immediately reflected by the white sand; finally, the wind-blown sand grains must cut or corrade the plants. He also mentions in detail how the plants are modified in order to withstand these difficulties, especially the excessive transpiration and the abilities of the plants to adjust themselves to the change of the level of the soil. Special attention is given to *Amophilia arenaria,* the characteristic plant of the dunes, and to *Corynephorus canescens* which is the characteristic species of the blown-sand flats.

Mr. E. Hesselink describes the first 33 photographs and Dr. J. Valckenier Suringar gives a detailed explanation of the other photographs which illustrate the individual plant species.

C. O. R. Spalteholz, *Cornell University.*

State Forestry Laws of 1922 and 1923. By J. S. Peyton. Circular 359, Forest Service, June, 1926.

This somewhat belated review (by the Forest Service) of 1922 and 1923 State Forestry Laws, is carefully compiled and unquestionably is of vital interest to all state foresters, teachers and others in public or semi-public service. The review shows that forest legislation is broadening, centering more upon continuous forest production than in the past. During these two years, thirteen states legislated on general organization, and activities and forest perpetuation "received more or less attention in twenty-three states" . . . General forest protection was agitated in seven states and special control measures were featured in California and New York. New blister rust control legislation was secured in Vermont, Idaho and Oregon. Fifteen states legislated to establish and maintain public forests and there was "an increasing realization of the need for bringing about the growing of timber . . . in private ownership." Mention was made of owners of 600,000 acres in the coast redwood region working out a plan for reforestation under expert advice.

The detailed classification and summary of legislation is under the following heads: administration, fire protection, public forests, taxation, protection from forest insects and diseases, state park and forest lands.

T. S. W., Jr.

Report of the Forester. Fiscal Year Ended June 30, 1926.

The annual report of the forester is, perhaps, the most interesting report ever issued, particularly in regard to policy and especially about "forest policies of large private owners." The forester states "in the South, particularly, an evolution appears to be taking place both in the attitude of timber land owners and in actual woods practice that is of very great import." Under conditions favoring the rapid growth and reproduction of pine that prevail in the South there is an unexampled opportunity for the practical growing of continuous timber crops.

The forester's report contains the usual statistics on fire danger, expenditures and receipts, grazing, sale of timber, etc. For the general administration and protection of the National Forests some 2.8 million dollars were expended, to which should be added 1.76 million dollars for the administration of timber grazing, land use, water power, and fish and game protection. Nurseries and tree planting cost 173.8 thou-

sand dollars while almost a million dollars were spent on research. The receipts for the use of timber forage land and water power totaled 5.15 million dollars, $150,000 greater than the preceding year. The increased receipts from timber were $426,000 while grazing, because of the poor market conditions decreased $404,000. A careful study of this report shows that the National Forest administration is being maintained on a high level of efficiency and that Federal Forest Administration is immeasurably ahead of the state forest services.

T. S. W., Jr.

NOTES

Forest Tree Breeding

By P. A. Herbert

Bates' popular article in the February issue of the Journal and Roeser's semi-technical one in the January, 1926, number, clearly point out the urgent need of breeding to improve the individual trees that make up our forests. Bates' assertion that ". . . between 25 per cent and 50 per cent of all forest planting in the United States to date represents wasted effort, . . . because of the use of poorly adapted species and races of trees," must seem startling to most foresters.

His suggestion to certify forest tree seed is excellent if it can be made effective. Certification as to the location of the seed bearing trees is practicable, but certification as to the character of the progenitors seems a more difficult problem, in that tree seed is collected here, there, and everywhere, and is not taken from thousands of plants grown together for that expressed purpose as is usually the case with plants producing certified field crop seed. Just how an inspector could satisfy himself as to whether the seed came from healthy trees or from ones with inheritable defects, without dogging the steps of each collector, is not clear.

The Forest Service can be very useful as a clearing house for forest seed information, especially by forecasting demand, informing collectors of good seed crop areas, and by placing buyer and seller in touch with each other. However, it is difficult to see how it, or any other agency, could allocate available supply, other than its own, on any other basis than demand and price, which, of course, will not always give distribution on a basis of "the permanent good of the forest."

It seems that the bulk of the forest tree seed could be collected by the nursery that is to use it, or by closely co-operating ones. The growth of large commercial seed houses has been due to the apathy and to the lack of knowledge by forest nursery men of the importance of seed origin. Seed is seed, to be purchased from the cheapest source available, and such seed is often collected from small suppressed and defective trees, or the lower branches of large trees, or from trees unusually favored by some environmental factor. The wider dissemination of the now existing facts on genetics and further experimentation will in time no doubt remedy the present condition.

Unfortunately, very few experiments are now being conducted in forest genetics. Persistent, and in this case, a mistaken demand for results has led most forest investigators to shun this field of research, even though the problems in forest tree breeding are so many and so diversified that the project is one of the few that could well be carried on by every forester in the country without fear of wasteful duplication. The practicing, administrative forester will find phases of this problem, especially in selection, that fit in well with his duties, require no special knowledge, and little, if any, extra time. The geneticist, on the other hand, will find trees the most difficult plant material to manipulate, making field crop genetics seem easy in comparison.

Past researches in tree breeding have been generally fragmentary and on the whole not very conclusive. Not only did they cover too short a period of time, but many were little more than general observations interpreted in the light of knowledge acquired in other branches of genetics. Roeser is undoubtedly right in his statement that selection is at present the phase of this problem that will and should receive most attention. Still, hybridization has distinct possibilities.

Beginning with Klotzsch, who back in 1845 successfully crossed Scotch and Austrian pine, we find an occasional research worker trying his hand at hybridization, although this phase was viewed with particular disfavor due to the long period necessary to obtain results. However, Dr. H. Ness, Professor of Botany at the Texas Agricultural College, who has already succeeded in raising three generations of oak hybrids, writes: "I am convinced that the breeding of oaks is pregnant with great possibilities, which are much more quickly obtained than one would suspect because of the early and complete fertility of so many of the hybrids in all generations."

Then, too, the extreme vigor of the first generation among our normally fast growing trees is also conducive of quick results. Thus, a specimen of the hybrid popple (*P. generosa*) created by Professor Augustine Henry of the Royal College of Science, Dublin, by crossing *P. angulata* and *P. trichocarpa,* has grown nine feet in two years in the nursery of Michigan State College. Even big business has seen the possibility—Dr. A. B. Stout of the Boyce Thompson Plant Institute, Yonkers, N. Y., is crossing popples at the behest and at the expense of a large pulp and paper company.

To successfully carry on extensive forest tree breeding research requires cooperation, and workers who have the requisite training and facilities to embark on long time experiments in security without fear

of discontinuance or the hampering cries for results. The Eddy Tree Breeding Institute of Placerville, California, endowed by Mr. James G. Eddy, a lumberman, and in charge of Mr. Lloyd Austin, a geneticist, seems to possess the requisites of workers, facilities, and stability, but they sometimes find it difficult to obtain necessary plant materials through cooperation. Similarly, Professor H. F. Roberts of the University of Manitoba, patiently laboring to enrichen the forest tree flora of the North must have sources of pollen from more southern locations to carry on successfully. Thus, foresters generally must lend a helping hand if headway is to be made on this problem during the Twentieth Century!

Dr. Schenck in Error

Editor:

I wish to call the attention of the readers of the Journal to a statement appearing in Dr. Schenck's article in the February issue.

In the paragraph on insurance the illustration that Dr. Schenck uses to prove his point is contrary to the facts. He states that a forest company ". . . should imitate the practice of an American railroad which does not think of ever insuring against destruction by fire, its station houses, its freight cars or its locomotives." As a matter of fact, that is just what they do; the only eastern road not carrying just such insurance written by the Railroad Syndicate (a combination of large stock insurance companies) is the Pennsylvania. The New York Central Lines with a capital value thousands of times as great as any existing forestry enterprise and a hazard much less than any forest business can ever hope to attain, finds it cheapest to carry commercial insurance.

P. A. HERBERT.

Less Mensuration—More Silvics

Editor:

Let me express my appreciation for your editorial, "Formulas and Common Sense." I believe that the preponderance of articles on mensuration in the Journal in the past has been the main reason for its lack of popularity.

As a "dirt forester" I want to make a plea for more publications on silvics. I realize that but little is known on this subject in this country but it seems that a compilation of what we do know would be of very great value.

Could not the experiment stations and the Journal work on this? A valuable article on the silvics and silviculture of a region need not be bulky. The tables which adorn most of our articles and bulletins

could be omitted. I suggest that a start be made on the Appalachian Region, both because of the complexity of silvicultural problems there and because I am personally interested there.

CLARENCE HILL BURRAGE,
Forester, University of Kentucky.

Schlich Memorial Fund

Prof. R. S. Troup,
School of Forestry,
University of Oxford,
Oxford, England.
My dear Professor Troup:

I refer to your letter of July 28, 1926, and my reply of October 14 last.

I am very glad to send you enclosed a draft on Barclay's Bank Ltd. for one thousand one hundred and eighty-one dollars and ten cents ($1,181.10), which has been contributed by foresters and friends of forestry in the United States to the memorial fund for the late Sir William Schlich. One hundred dollars of this amount was subscribed by the Society of American Foresters as an organization. The remainder has been subscribed by individual foresters and groups of foresters representing practically every section of the profession in the United States. Contributions have come in from a number of local sections of the Society of American Foresters, from forest schools, from state departments of forestry, and from practically every group of foresters engaged in the various bureaus of the federal government. A number of men who are not professional foresters themselves but who are associated with forestry work in the United States have wanted to have a part in the memorial to Sir William and have forwarded contributions. This is particularly true in the case of the field service of the Forestry Branch of the Bureau of Indian Affairs, as well as in several other instances.

The foresters of the United States are very happy to have a part, although a small one in financial terms, in this recognition of Sir William Schlich's professional services and his inspiration to English speaking and reading foresters all over the world. We are also happy to join with our fellow foresters in Great Britain and the British Dominions in a bit of international goodfellowship that I trust is indicative of closer personal and scientific relationships helpful to the progress of all English speaking nations in forestry.

I have received a number of suggestions as to the character of the Schlich Memorial. The plan which is most widely, indeed universally, commended is to use the major portion of the fund to endow a scholarship at Oxford for the assistance of deserving students of forestry or for graduate work, open to men from any of the English speaking nations. In my own judgment this would be particularly appropriate. The erection of a memorial tablet to Sir William Schlich, at Oxford, or the planting and care of a memorial tree, or both, would also, I am sure, meet with general favor from the foresters in the United States.

We all trust that your efforts to provide a suitable memorial for Sir William will be crowned with success.

With very warm personal regards,

Very sincerely yours,

A. B. Greeley.

Forest Service Eliminated from Proposed Department of Public Works and Domain

Some misapprehension may exist among the members of the Society as to the inclusion of the Forest Service in the proposed Department of Public Works and Domain, sponsored by the American Engineering Council. As a matter of fact, the report of the Council's "Committee on Organization of Public Works," dated November 1, 1926, does carry such a recommendation with the note "except the silvicultural functions."

President Stuart of the Society, however, has been advised by Secretary Wallace of the American Engineering Council, that the Council had decided some time ago not to include the Forest Service and that it would continue to be guided by that decision.

The Wyant bill which embodies most of the recommendations of the report does not mention the Forest Service. This bill was approved at the recent annual meeting of the Council.

The Garrett-Hawes bill calling for the establishment of a Department of Conservation, and introduced late in the last session of Congress, would include in such a department the Forest Service, Bureau of Biological Survey, National Park Service, Bureau of Fisheries, and those National Monuments now under supervision of the Forest Service. This bill is sponsored by no particular organization as far as can be learned, but more than ordinary interest is manifest in it by prominent members of Congress.

There is one conflict between this bill and the Wyant bill involving

the National Park Service, which is included in both. A logical inclusion in a conservation department would also be the disposition or regulation of certain resources on the public domain such as forage. This again would bring the bills into conflict. The Wyant bill would replace the present Department of the Interior while the Garrett-Hawes bill would create an additional department. It is probable that the Society will be asked to study and comment on both measures.

National Committee on Legislation

The National Committee on Conservation Legislation, formed in Washington, December 8, 1926, got under way a bit late to function aggressively during the 69th Congress.

President Stuart took part in the organization meeting and two members of the Society are representing other organizations on the "Washington sub-committee" appointed to push important measures. The sub-committee made a canvass of the Senate on the McNary-Woodruff bill to uncover any newly developed opposition and worked in close cooperation with the American Forestry Association in a final effort to get the measure through. It was lost through delays caused by Senator Overman's opposition and because of the filibuster which prevented Senate concurrence in the final House amendment. The securing of a favorable vote on the bill by both houses, will, it is hoped, influence the Bureau of Budget in its recommendation of acquisition funds for 1928.

The future of the National Legislative Committee is not yet worked out but the past season's experience forms a good background for its continuance. The relation of the Society to the committee is a matter for careful thought and comment by the members.

Sections of the Society of American Foresters for 1927

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J. H. Preston, Vice-Chairman, c/o Hammermill Paper Co., Erie, Pa.
H. F. Round, Secretary-Treasurer, Forester's Office, Pennsylvania R. R. Co., Philadelphia, Pa.

California

C. L. Hill, Chairman, 1408 Grand Ave., Piedmont, Cal.
F. S. Baker, Secretary, 305 Hilgard Hall, Berkeley, Cal.

Central Rocky Mountain

E. W. Tinker, Chairman, Forest Service, Denver, Colo.
J. W. Spencer, Vice-Chairman, Forest Service, Denver, Colo.
H. D. Cochran, Secretary, Forest Service, Denver, Colo.

Gulf States

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Roy G. Pierce, Member Executive Committee, Bureau of Plant Industry, Office of Blister Rust Control, Washington, D. C.

Wisconsin

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F. G. Wilson, Secretary, Agricultural-Engineering Bldg., University of Wisconsin, Madison, Wis.

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